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UNITED STATES NUCLEAR REGULATORY COMMISSION'S
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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SUBCOMMITTEE ON RADIATION PROTECTION AND

NUCLEAR MATERIALS

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FRIDAY

JULY 22, 2022

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The Subcommittee met via Teleconference, at 9:30 a.m. EDT, Gregory H. Halnon, Chairman, presiding.

COMMITTEE MEMBERS:

GREGORY H. HALNON, Chairman

RONALD G. BALLINGER, Member

VICKI M. BIER, Member

CHARLES H. BROWN, JR., Member

VESNA B. DIMITRIJEVIC, Member

JOSE MARCH-LEUBA, Chairman

DAVID A. PETTI, Member

JOY L. REMPE, Member

MATTHEW W. SUNSERI, Member

ACRS CONSULTANTS:

DENNIS BLEY

STEPHEN SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

WEIDONG WANG

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P R O C E E D I N G S

9:30 a.m.

MEMBER HALNON: Good morning, everybody. My name is Greg Halnon. I'm the Subcommittee Chair for this meeting this morning. The meeting will now come to order. This is a meeting of the Radiation Protection and Nuclear Materials Subcommittee of the Advisory Committee on Reactor Safeguards. ACRS members in attendance are Charlie Brown, Davie Petti, Jose March-Leuba, Joy Rempe, Matt Sunseri, Ron Ballinger, Vesna Dimitrijevic, Vicki Bier; and then we have consultants, Steve Schultz and Dennis Bley also present. Weidong Wang of the ACRS staff is the Designated Federal Official for this meeting.

Did I miss any of the ACRS or consultants? Okay, good.

During today's meeting, the subcommittee will hear a staff informational briefing on the development of Reg Guide 1.249, Revision 0, use of ARCON Methodology for Calculation of Accident-Related Off-Site Atmospheric Dispersion Factors. The subcommittee will hear presentations by and hold discussions with the NRC staff and other interested persons regarding this matter.

The entire meeting will be open to public attendance. This meeting is for an information briefing, and no actions are expected from the ACRS full committee. We asked for this briefing due to the numerous regulatory activity surrounding source term determination, the LPZ sizing, advanced technologies being reviewed, and other code changes.

With the interplay of reg guides both in revision, planned for development, and guidance for the new Part 53, it is important for the ACRS to stay aligned with the staff and the applicants on the use of calculational methods, such as this.

The rules for participation in all ACRS meetings, including today's, were announced in the Federal Register on June 13th, 2019. The ACRS section of the U.S. NRC public website provides our charter, bylaws, agendas, letter reports, and full transcripts of all full and subcommittee meetings, including slides presented there. The meeting notice and agenda for this meeting were posted there, as well.

We have received no written statements or requests to make an oral statement from the public. Today's meeting is being held over Microsoft Teams, which includes a telephone bridge line allowing participation of the public over their computer using Teams or by phone. There will be an opportunity for public comment, and we have set aside some time at the conclusion of the prepared presentations and member discussions for public comment.

The transcript of the meeting is being kept, and it is requested that the speakers identify themselves and speak with sufficient clarity and volume so that they can be readily heard. Additionally, participants should mute themselves when not speaking. To mute and unmute on a phone, please push star 6.

Do any of the members have any introductory comments?

Okay. We will now proceed with the meeting, and I'd like to start by calling on Kevin Quinlan of the NRC staff for opening remarks and presentation of the material. Kevin, it's all yours.

MR. QUINLAN: Thank you. And good morning, everybody. I appreciate this opportunity to present to the ACRS on this topic. I will be giving the first portion of the presentation, but I just wanted to let you know that Jason White is on the phone and he will be, we will be co-presenting this, so we will be swapping back and forth a couple of times in the presentation. I'll be controlling the slides from my computer, but Jason and I will each be giving the presentation.

So let me first introduce myself. I'll give Jason the opportunity to introduce himself. So as I said, good morning. My name is Kevin Quinlan. I am a meteorologist in the External Hazards Branch in the Office of Nuclear Reactor Regulation. I've been with the agency since 2008 and have spent most of my time reviewing new reactors, operating reactors, license amendment requests, mostly in licensing space.

During the presentation, I will be in presentation mode on my computer; so if you have any questions, you know, feel free to interrupt me. I likely will not be able to see if somebody raises their hand to ask a question or if somebody puts something in the chat. So if somebody could alert me that there's a question, please do and Jason or myself will do our best to answer it fully.

I will be using my pointer, which I have changed to the red dot. So, hopefully, everybody can see it clearly. Since this is not in person and I can't talk with my hands, I will be talking with my pointer at times.

So, Jason, if you'd like to introduce yourself.

MR. WHITE: Yes, good morning. I'm Jason

White. I'm also a meteorologist in the External Hazards Branch in NRR, and I've been with the agency since 2009.

MR. QUINLAN: All right. Thanks, Jason. So, first, as you can see, the title slide. This is the draft Reg Guide 1.249, the Use of ARCON Methodology for Calculation of Accident-Related Off-Site Atmospheric Dispersion Factors. I thought I'd just start with a very brief purpose and need, if you will.

Through the evaluation of two different topical reports, the NRC staff had determined that the ARCON computer code is acceptable for modeling exclusion area boundary and low-population zone chi over q values just to add strict dispersion values at relatively short distances, as long as the methods were consistent with the regulatory positions in our existing guidance. The brief history on this is that the ARCON computer code was, until recently, only used to estimate the atmospheric dispersion from an on-site source, such as a vent or a stack or a door, to the control room intake or the technical support center. So there was a bit of a change in the way that the code was used. This draft reg guide aims to provide clear guidance to the nuclear industry on an acceptable method to use the NRC ARCON code or methods to estimate off-site atmospheric concentrations to the EAB and the LPZ.

So that's the kind of the impetus that drove the creation of this draft reg guide. There was a change in the way that the ARCON code was used from a control room habitability and control room dose code to using it for off-site does.

DR. BLEY: Kevin.

MR. QUINLAN: Yes.

DR. BLEY: This is Dennis Bley. As I read it, it sounds as if there's been no changes, even with the new version of the code, there's been no changes to the models that are inside it. Were they always available to use this way, or were there some changes to the code to use it for things beyond the control room kind of calculations?

MR. QUINLAN: Sure, no, excellent question and perfect timing on kind of the setup. So you're correct. There were no changes to, there were no changes to the code itself. We are using the exact same version of the code.

You will see in the reg guide sometimes it's referred to as ARCON96 because that is what the guidance calls it. We recently updated the code to

ARCON2. Now, that code, the update to ARCON2 did not change the dispersion algorithms within the code. It really just put a new graphical user interface on the front, making it usable on newer versions of Windows. We were having problems with the previous version and it being used on modern operating systems.

So there were no changes to the code. And I suppose, to partially answer your question, there was always the opportunity that an applicant could use this code for purposes outside of the control room habitability, and that's exactly what happened. We had an applicant decide that their exclusionary boundary was fairly short, and we'll get into this in the slides. But there on the order of, you know, 80 to a couple of hundred meters, rather than the, you know, 500 meters to a 1,000 meters for the exclusionary boundary that large light-water reactors have.

So the smaller designs with their smaller source term decided that they could have smaller site boundaries. And so, therefore, they decided to use a code that was more designed for those shorter distances.

DR. BLEY: And being designed for the shorter distances, my memory of this stuff is that it's able to take account for the impact of building it and building wakes on dispersion. Beyond the site boundary, you don't worry about that so much. Is that correct, or is there something I'm missing here?

MR. QUINLAN: No, no, you're correct. The ARCON code does a better job of capturing the effects of buildings and building wake on plumes. So that's why it was always used on-site, going from, you know, one of the support buildings or the buildings on site that may have a release, the turbine building or something like that, to the control room intake.

DR. BLEY: Okay, thanks. That helps. I think you said this, but the reason you want the reg guide now is because, with some of the new designs we're expecting, there's going to be more of the same kind of calculation going on, I'd expect.

MR. QUINLAN: Correct. So we've now seen it twice. Two different applicants have come in with topical reports that the staff has reviewed. Jason actually has, so he will be able to, he could probably answer questions more specific to applications than I can, but two separate applicants have come in with topical reports to use ARCON for off-site chi over q estimates. So the staff wanted to develop a reg guide to avoid the potential that we're going to have, you know, say we get 20 applications in so we'd get 20 different takes on how to use ARCON for this purpose. So we would like to provide an acceptable method to the staff to try to cut down the number of unique versions of this method. It would save us time, it would save the industry time and money, and so, you know, we thought a reg guide would be a useful tool to get out ahead of where the industry is already going.

DR. BLEY: Okay. Thanks a lot. That really helps put this in perspective for me.

MR. QUINLAN: Sure. I'm happy to keep on talking. I talk quickly, but I talk a lot, so I'll try to keep us on track here.

All right. Moving on. So the general outline will be an overview of atmospheric dispersion, so really not specific to this reg guide but more of a what is atmospheric dispersion; how is it calculated; how is it used in siting and design; the second bullet there; how is our current guidance used; how does our current guidance use chi over q values for the EAB and the LPZ; and then a little bit of discussion on the relationship with other atmospheric transport and dispersion -- that's what ATD stands for, atmospheric transport and dispersion -- regulatory guides, how it relates to this new version of Reg Guide 1.249. Then Jason will be talking about the expanded use of the ARCON code for this new purpose, how the new reg guide will be used; and then he'll switch back to me and I will walk you through an example calculation of an acceptable method that the staff sees for how this can be used. And I'll apologize ahead of time and I will apologize later that I will be talking about math on a Friday morning as part of the example calculation, but it is, unfortunately, unavoidable.

So moving on. Start with an overview of atmospheric dispersion. So atmospheric transport and dispersion modeling, you can see here it's the top of the food chain here. And it encompasses atmospheric transport or advection. Those words are used interchangeably. Diffusion, so it's a little more of a molecular diffusion that plays a very, very small part. Removal, which can be done through either dry or wet deposition that will not be talked about in this presentation because ARCON does not consider precipitation, nor does the previous code, the PAVAN computer code, which has been historically used for off-site dispersion that also does not consider rain-out or washout or precipitation in any way. And then transformation, you know, once it's on the ground, talking about, you know, shine.

DR. BLEY: Kevin.

MR. QUINLAN: Yes, sir.

DR. BLEY: ARCON only does lighter-than-air gasses, right? Or can you do both, heavier than air and lighter than air?

MR. QUINLAN: So ARCON doesn't actually consider what you are transporting at all. It is strictly a measure of the dispersion in the atmosphere and it only considers the wind speed, the wind direction, and the atmospheric stability. And so it's a measure of the dispersion in the air. That is then used by the dose assessors to determine the resulting dose at a given location. So the dose assessors would basically multiply the chi over q value here, the concentration factor, which is what comes out of ARCON, by the source term. But ARCON itself doesn't, there is no input for a given gas, either lighter or heavier than air, one way or the other.

DR. BLEY: Okay. Thanks.

MR. QUINLAN: Sure.

MEMBER BIER: Another quick question. This is Vicki Bier. So in uncertainty analysis for transport and dispersion, there would, of course, be uncertainty about what the weather conditions would be and you could run it for numerous different weather conditions. For a given set of weather conditions, is chi over q taken to be a constant and is it well enough understood that the variation around that would be very small?

MR. QUINLAN: It's an excellent question. It's slightly outside of what ARCON does. ARCON is not a probabilistic model. It is a deterministic model in the sense that it uses actual recorded meteorological observations for the calculations. So it uses at least one year of data to characterize the dispersion at a given site.

MEMBER BIER: Okay. But it does it by kind of averaging or smoothing over all the different weather conditions.

MR. QUINLAN: So it considers each hour of data, 8,760 per year, as its own unique chi over q value. And then you can rank them to -- we'll get to it in a couple of slides, but you basically pull out a very conservative value once you rank all of the hours and the individual chi over q values for each of those hours. We pull out either the 95th percent value overall, so for the entire site, or a 99.5 percent value, which considers the top, I believe it's top 44 hours in any given year. So we pull out an extremely conservative measure of the dispersion for a site, and that's what gets used to calculate the resulting dose.

MEMBER BIER: Okay. Thank you.

MEMBER PETTI: And, Kevin, I was going to say that any sort of experimental uncertainty in those measurements that are done are small relative to this, you know, the way that you're using the data and going out to 95-percent confidence.

MR. QUINLAN: Right. So I'm not sure I would use the term 95-percent confidence in this because, again, it's not probabilistic. It is a ranking of the number, ranking of the hours and pulling out a conservative value. And that gives us the confidence that the resulting doses due to the chi over q is used is likely to be the extreme case for any given year.

MEMBER PETTI: Right. Okay.

MR. QUINLAN: All right. Moving on. So this is cartoon of really all the different factors that go into an atmospheric dispersion assessment. We certainly discussed some of them just a moment ago. This is depicting a stack. Normally, for ARCON runs and PAVAN runs, we consider a ground-level release, but this does a little bit better job of depicting what could potentially go into the transport of radionuclides released to the atmosphere. You have your infection, which is driven by the wind, and that's considered to be constant for each hour. You have your molecular diffusion, which, again, plays a very, very small part. Most of the transport is through the wind. There's the rain-out and washout. Now, again, this is not considered in PAVAN or ARCON, but, certainly, the turbulent eddies. You know, this is a large part of the strength of ARCON. It considers turbulent eddies mainly through the building wake effects, so how that affects the plume. And then, certainly, dry deposition, wet deposition, but ARCON does not consider those.

DR. BLEY: So when you indicated the calculations are conservative condition, I guess we're thinking, at least we were thinking, of effects on control rooms such that rain-out would get it out of the air, and so you're not considering that, so that means that that mechanism for removal isn't there. But if we're talking about shine dose to people who are outside of the control room, then not including rain-out seems to go in the other direction.

MR. QUINLAN: Yes, I certainly understand your point. That may be a good question for me to run by -- I am not a health physicist. I'm a meteorologist by degree. So once you start getting into doses from shine due to either ground shine or sky shine due to wet deposition or dry deposition, that starts to get a little bit outside of my comfort zone. But I certainly do understand your point, and I think it's a good one.

DR. BLEY: So the data input when you run ARCON is primarily a wind data; is that right? Or are there other parts of weather that are coming in?

MR. QUINLAN: Sure. So it's an hourly data file, and it consists of wind direction, wind speed, and a measure of the atmospheric stability.

DR. BLEY: Okay.

MR. QUINLAN: And I'll be getting much more into how we calculate the atmospheric stability because that is, you know, quite important to these calculations.

DR. BLEY: If you can, follow up on that one because if we're beginning to use this for, like, dose at the boundaries, then not having the shine dose from washout might really give us optimistic answers. I'm curious about that.

MR. QUINLAN: Sure. So I might add now, but it is certainly a good question to follow up, is that PAVAN, which has been used since 1982 for off-site chi over q calculations to the EAB and the LPZ, also doesn't consider shine in any way, shape, or form. So this is in, use of ARCON is in very close agreement with the assumptions that have been used for 40 years now for off-site doses.

DR. BLEY: That's interesting. Okay. I'm more familiar with how this stuff --

MR. QUINLAN: I don't know if that makes things better or worse.

DR. BLEY: -- and, there, they do account for those pieces. Okay, go ahead.

MR. QUINLAN: Sure. This is really just another way of looking at the exact same figure. So we really start with the on-site measurements, which are taken by the on-site meteorological measurements program, a meteorological tower on-site. We require one-year minimum from our guidance. We do typically see two years or more for any application, but there's a one-year minimum there. That feeds directly into the transport of the wind, the advection that we talked about; diffusion caused by atmospheric turbulence, so those were the turbulent eddies that we talked about; both thermal eddies and mechanical eddies, and I'll be talking about those probably, I believe, on the next slide a little bit more.

DR. BLEY: So I'm sorry. Right there.

MR. QUINLAN: Yes.

DR. BLEY: Another input beyond the weather must be the building, the structures --

MR. QUINLAN: Correct. And I will show you the input, I'll show you the input screen in a couple of slides from now, which will show you all of the different site-specific inputs, in addition to the weather data that goes into it. So, hopefully, that will answer any questions you might have.

DR. SCHULTZ: Kevin, this is Steve Schultz.

MR. QUINLAN: Sure.

DR. SCHULTZ: Do you have, are you going to be talking more about the one-year minimum and the various ways in which the applicant can provide information related to their measurement, on-site measurements, and so forth? It seemed in the document, as well as in the comments from the public and the resolution of it, that there was a lot of discussion about how this is done and many, many different types of options. It seems like this is one area where the staff and the applicant will need to have some real dialogue in order to gain approval of their use of the code.

MR. QUINLAN: Yes. So Jason will be talking a bit more on his slides about the use for or the use of, I suppose we could call it nontraditional observations. And not to steal Jason's thunder, but the reason that we included that in the regulatory guide is that, historically, we have reviewed large light-water reactors and they have large EAB and LPZs. Every single one has an on-site meteorological tower, and they, you know, if they're looking to expand upon existing units, then they already have the existing tower. If they're looking to build new units at a greenfield or a brownfield site, they'll typically put up a tower a couple of years ahead of time, start collecting the data, and then submit that with their application. It's always been very cut and dry.

Lately, we've been seeing a little bit more of a push from the industry to use other data observations, whether it be from the National Weather Service or another source. For example, up at Idaho National Lab, there was some talk about potentially using the DOE, they have a network of weather and observation towers at Idaho National Lab, so that would be DOE data. We've had a site down in Tennessee that wants to use Oakridge National Lab data. There was just a site up in Wisconsin that used National Weather Service data from a nearby airport.

So we're starting to see a little bit more of a direction in the industry of wanting to use off-site data, if you will, and trying to think ahead for where new small modular reactors or advanced reactors may be deployed in more nontraditional locations. There's been discussions about deploying these, you know, advanced reactors up in Alaska.

So these sites don't necessarily have on-site met data. It may be very difficult to begin collecting on-site met data. So we wanted to provide some guidance to the industry on how to or what would be an acceptable use of non-on-site data. I still think the most straightforward path for the industry and for any specific application is to use an on-site met data system. It's on-site, so you know it's applicable. It's under their control. We have a reg guide, Reg Guide 1.23, that talks specifically about what goes into an on-site system, so it is a bit of a cookbook. You just follow the recipe, and it will come out. But we thought it was important to include nontraditional observations, considering where the industry seems to want to go.

DR. SCHULTZ: Thank you. And I'll wait

for Jason's presentation, too. It's obviously a very important feature associated with the overall evaluation.

MR. QUINLAN: It is. And so we did spend a good portion of this reg guide discussing it, mainly because it is -- the use of ARCON is not new. It's been used since the mid-90s. But the use of non-on-site data, or I guess I could say off-site data, is new. So we wanted to spend time on that and make sure that we got that right and an acceptable path for the industry.

So the way that ARCON is being used is new, but the code itself is not. But, you know, the met data is a bit of a new feature.

DR. SCHULTZ: Thank you.

MR. QUINLAN: Sure.

DR. BLEY: And, Kevin, I'll get out of your hair in a minute.

MR. QUINLAN: No, no, you're fine.

DR. BLEY: One last question from me on this. In the next line, you have the stability, and are we still using the kind of course Pascal categories, or are they doing something more directly measured now for stability?

MR. QUINLAN: I would ask you to hold that thought --

DR. BLEY: Okay.

MR. QUINLAN: -- for at least three or four more slides, and I will answer it. If I don't answer it, then please just let me know.

CHAIRMAN BROWN: Are you finished with this slide? I wanted to ask you a question -- this is Charlie Brown -- before you shift off.

MR. QUINLAN: No, go ahead, please.

CHAIRMAN BROWN: On your first one, on-site measurements, why is it only a one-year minimum? I would think that you would want to see some, at least some variation over a larger period of time in terms of what the atmospheric conditions are. Is there a basis for selecting one year only to do your analysis?

MR. QUINLAN: So for certain applications, we require different time periods. And I apologize I don't have the regulatory guide up in front of me. Regulatory Guide 1.23 specifies certain time periods for certain types of applications. So for, like, COL and early-site permit applications, there is a two-year minimum.

And so what sometimes we will do is, say an applicant won't have two years' worth of data when they submit, so we'll review the application and the other portions while they collect their second year, and then they'll supplement their application with that second year of data. We've done that a few times, and I was just asked that question by a new applicant this week.

But other types of applications do require one year minimum because it's not necessarily site-specific. So for things like a construction permit -- I'm sorry, not a construction permit, a design certification where they don't have a specific site picked out and maybe they're considering a variety of sites that they could potentially deploy to, you know, at that point, one year of data is probably fine, especially if you're considering a number of different sites and you're trying to prove the adequacy of the kind of the proof of concept of the design itself. We've seen plenty of designs, you know. The AP1000, for example, could be sited in a number of different sites. We wouldn't require multiple years of data for every single site that they came in with. You know, we would probably look for one year of data for each site just to prove that it could be sited at a variety of locations.

CHAIRMAN BROWN: So, I mean, it would seem to me that we can get over a 40 or 50-year period, you can get a considerable variation just based on general changes that we observe. Nothing is really ever constant. You can look at the normal weather we face. We had big years and faulty years, and it varies over a 10, 15, 20-year period. So that's why I have the question. That's why I think that the dispersion issue for the atmosphere would be of interest to make sure you didn't miss -- kind of like earthquakes, you know. The last big earthquake might have been 300 years ago, but you'd like to know at least it was that long ago. So that's why I -- I'm not looking for 300 years; that's not the point.

MR. QUINLAN: That's good because, when it comes to weather data, you're not going to get it. No, I certainly understand your point, and I think it's a good one. I just looked up the time periods for a construction permit. It's a 12-month period. Operating license, 24 months, so a two-year period. Early site permit, COLs, are 24-month periods.

But one of the things that we -- that's not really the last step, if you will. So the period that is collected and submitted with an application for analysis has to be within the last 10 years, so we want to make sure that -- at a site, conditions change, buildings go up, buildings come down, trees grow all the time and they tend to surround the weather station. You know, you're always worried about upwind and downwind impacts on weather observations, so we want to make sure that it's relatively recent, so within ten years is what our guidance says.

But then what we do is we go back and we compare the data that is submitted for atmospheric transport and dispersion modeling with a recent, we call it a climatic period, so it's a 30-year data set from a nearby airport or a nearby National Weather Service, FAA, DOE, you know, a reliable quality-assured data set that goes back at least 30 years as part of the application. And what we do is we make sure that the observations that are collected on-site and submitted for ATD modeling are representative of the area and other longer-term data sets in that area.

DR. BLEY: And if they're not, how do you handle that? Do you have the applicant run a case, say out of that data set that's either very much lower winds or very much higher winds, or what do you with it if this is not, in a sense, representative of all the years in that 30-year period?

MR. QUINLAN: Well, we certainly, you

know, we would take a closer look at the data and perhaps they would need to consider a more limiting chi over q value, a more extreme version. So keep in mind, this is one part of the dose assessment puzzle, so there's the source term, there is the atmospheric transport modeling, there's the receptor. And so you put all those together to come up with a dose at a location over a certain amount of time.

So we would certainly compare what they're modeling against the regional data, but also compare it against the dose requirements, you know, the dose limits and say, all right, if it's a 1 rem with a 20 rem dose limit, you know, will it make a difference if we use a more conservative assumption in the modeling or, you know, raise the chi over q by some percentage to account for the difference in the weather data.

I'll be honest. In the 14 years I've been at the agency, it really hasn't happened. Typically, the on-site data is high quality and is fairly consistent, at least with wind direction, wind speeds. So we do have a measure of confidence that the data collected at the site is representative of the area, but I think we would then need to probably add in some extra conservatisms if it was not.

DR. BLEY: That makes sense, and that kind of explains the spot you're in. You haven't seen it. If you do see it, you'll have to figure out what to do.

MR. QUINLAN: Much like some of the other areas that we deal with, yes.

MEMBER HALNON: Okay. Kevin, we're running behind. We've used up well over 30, almost 40 percent of our time, and we're only on slide six. So we need to kind of continue to move on, although the conversation is exactly what I hoped would happen. So let's move on, and we'll pick up a lot of these questions as we go.

MR. QUINLAN: Yes, I think we certainly will. So this slide is really another way of discussing what we've been discussing, but it gets a little bit more into specifics of gaussian plume modeling, which ARCON and PAVAN both are. They're both gaussian plume models.

It has been historically and widely accepted at the NRC for use in radiological assessments mainly because they're fast, because they're simple, and they only require a few input parameters. And so PAVAN has been used since 1982, ARCON has been used since 1996. They're quick and they're easy, and they provide a very conservative estimate of the atmospheric dispersion for use in these assessments.

So some of the assumptions that go into these models are that the emission rate is constant. Again, I said earlier we're not considering a specific gas or a specific affluent, but whatever it is it's considered to be constant. The horizontal meteorological conditions. They're homogenous over the entire space being considered, so this isn't computational fluid dynamics. This is a street line model. And we model one hour at a time, and the average wind speed for that hour is used. There's different ways of averaging, but I won't get into that. We have reg guides that discuss how it should be averaged.

We assume the wind direction is constant, again, over that one hour. The atmospheric turbulence or stability is also constant over that hour. There's no wind shear in the horizontal or vertical. The plume is infinite, and there's no plume history. Again, each hour considered on its own merits.

Dispersion in the Y and Z directions of a gaussian, it has a gaussian normal distribution. And diffusion is negligible in the downwind again. We're, you know, looking at more transport and dispersion instead of the diffusion, molecular diffusion.

And this is a diagram of exactly what I just talked about. And it's similar to the other one, but I wanted to point to here is wind going, like I said, towards the top right of your screen, there's a plume center line. There is the X axis and the Y axis, the gaussian distributions which will create the entire plume. There is no plume rise calculated in ARCON. An operator or whoever is running the code can estimate the plume rise by just really raising the height of the release. So you can kind of see how the plume will spread out in a gaussian fashion both in the X and Y directions.

DR. BLEY: A quick question here. If at hour five the real wind actually changed direction, you just assume it's moving in the same direction it was, do you apply different stability factors hour by hour, or when you get a new one at hour five do you recalculate the whole plume?

MR. QUINLAN: So every hour will consist of a wind direction, a wind speed, and a measure of the atmospheric stability. So each hour you calculate a chi over q for that hour, and then they get ranked, all those hours, all the 8,760 hours get ranked and we pull out a very conservative 99.5 percent highest value.

So you are correct. If at hour five, the wind direction changes and the stability changes, as happens all day long. You look out the window now and it's breezy, it wasn't breezy four hours ago before the sun rose. So every hour is considered on its own and then is ranked on its own, and then we pull out the most conservative values, and that's what we assume is used during a design basis accident release.

DR. BLEY: Okay. Thanks.

MR. QUINLAN: Absolutely. That's a good question, sir.

So getting a little bit more into the atmospheric turbulence or stability, causes primarily are, at least what we consider to be ground heating and cooling, which is what I talked about. The sun comes up, it heats up the ground. You start seeing some breezes. That's why you get those nice afternoon cumulus clouds. It's those turbulent eddies in the atmosphere that are causing that.

It can also be done by the mechanical turbulence. Now, this roughness here, in reality, yes, that's due to trees, it's due to buildings, and whatnot. For ARCON purposes, it's buildings. It's the building wake effect of how air moves over and around a building and what that can do to a plume in the atmospheric.

So we have a couple of different ways of measuring the atmospheric turbulence. Indirect measurements, which is the wind speed; solar radiation or sky coverage during the day; net radiation or sky cover at night. This is the old Pasquill-Gifford method where if you don't have two measurement heights for temperature to compare, you can try to do a rough estimate of the stability class based on the sky cover and the wind speeds. So that's what that's talking about.

The one that we use in our guidance and that ARCON is based on is the delta T method. It is the delta T standing for the change in temperature. So you'll have a meteorological sense, a thermometer at, typically, 10 meters above the ground and 160 meters above the ground. You compare the height, you calculate the difference between the two, and that gives you the measure of how stable or unstable the atmosphere is.

There are some other direct measurements that you can make based on horizontal wind speed and how the horizontal and vertical wind speed changes, but our models and our guidance really focuses on the delta T. And I will get a little bit more into that right here.

So this is temperature on the X axis, height on the Y axis, and you can see, you know, as everybody knows, typically, as you go up in the atmosphere, the temperature decreases. As an ideal gas law, as it goes up, the pressure decreases, the partial, if you will, will expand and cool. So this is a way that we look at the changing temperature of the atmosphere. So as it arises, it cools. If you have warm air at the surface and cold air up here, the warm air will rise and that will start, it will go up, and that means air has to come down, and you will start a daytime circulation. Again, those afternoon puffy fair-weather cumulus clouds are exactly this; or if you've ever landed on a plane, you can see that you're about to get down towards the boundary layer by those clouds, and that's when it gets bumpy at landing. But if you have warm air up here and cold air down here, then there's nothing driving that circulation, so the atmosphere is considered to be very stable. Air is not going to be moving up and down, you're not going to get the wind associated with those eddies.

So the difference in, the temperature

difference between those two levels is what drives the atmospheric stability. We classify them into different categories, A, B, and C being very unstable. So typical conditions, midday, strong sunshine, light wind which will allow you to heat up the surface more. You'll have a heat flux that moves upward, as I just discussed, and you end up with considerable horizontal and vertical turbulence. That's when you see plumes really spreading out, and I'll have some pretty pictures in about two or three slides to show you just that.

Mutual stability right in the middle is when it's windy. The atmosphere is very well mixed. There is no temperature difference between the upper and lower boundary layer in the lower atmosphere because it's already mixed due to the wind, or if it's cloudy then you're not going to get that solar insulation, that solar heating. Very stable conditions happen at nighttime: clear air, light wind. You don't get that vertical motion, so the atmosphere is extremely stable, so if you do have a plume it's not going to rise. It's going to stay near the surface. And so our light wind conditions and G stability, which is extremely stable, are really what drives the highest chi over q values. So when I talk about ranking the chi over q values across, almost all of these get thrown out, to be honest. Our, roughly, one meter per second at G stability, that's what is going to drive the worst dispersion conditions at a site and will lead to the highest doses, so that's what's considered, for the most part, in a design basis accident assessment.

This is another way of looking at it. So unstable conditions, you get those turbulent eddies with the plume going up and down and really spreading out in the X and Y directions as it goes down wind. And you can see here temperature, warmer at the surface than it is aloft, so you get the turbulence.

The neutral, there's really not that much difference between the surface and the atmosphere right above it, so it spreads out in a nice, pretty gaussian fashion right here, just what you would expect. The extremely stable conditions, E, F, and G, where the ground is cooler than the air aloft, and that plume is not going to spread out much. It's going to stay close to the surface. It's going to stay in a straight line. Whichever wind direction is blowing, that's where it's going to go. So if you picture a ground level release instead of the kind of stack that's depicted here, you can imagine that

that's where you're going to calculate your worst dispersion conditions and that's where you're going to get your highest chi over q values.

DR. BLEY: Kevin, that picture looks really familiar to me. There was an old, probably in the early 60s, NRC manual on meteorology. I don't know if it was a NUREG or a watch document. Is that still relevant, or has the science changed a lot since then?

MR. QUINLAN: Well, how we model them has changed, but the science is exactly the same. I mean, this is all fluid dynamics, just in the atmosphere. So that would be the same. We still use Skew-T diagrams to explain changes in temperature in the atmosphere.

The way that things are calculated are much more complex now, a little bit more advanced. But these same assumptions still hold very true.

DR. BLEY: That old handbook has never been updated, has it? Are you even familiar with it? It was --

MR. QUINLAN: I have a copy of it myself; I do.

DR. BLEY: Okay.

MR. QUINLAN: And this probably looks

familiar because I'm sure that this came from that, yes.

DR. BLEY: That's what I thought. Go ahead.

MR. QUINLAN: You're exactly right.

MEMBER BIER: I have another question on that previous slide. It gets exactly at something that I was thinking about.

MR. QUINLAN: Okay.

MEMBER BIER: If we are modeling dispersion like, I don't know, five miles downstream off-site some place, then it seems really clear that that top unstable condition will have lower dose concentrations just in general, once you get that far downstream. But if you're talking about either on-site or very close to on-site, I mean, you show this variability up and down, but I assume there's also variability laterally.

For instance, in your top picture, the dose where it looks like the plume is hitting the ground is higher in the unstable than in the neutral and stable, right? Because the instability kind of push the radiation into a pocket that wouldn't otherwise have had high levels of radiation. So I wonder if that's a kind of general issue with this method for short dose predictions.

MR. QUINLAN: You are exactly correct, and I'm finding a Section 2.3 of the draft reg guide is called release characteristics, and it talks about exactly that issue that you just raised. I think you've captured it perfectly where, if you have an elevated release, something from a stack, and you have your, let's say, EAB boundary is right here, you're missing the plume. You're not going to, it's going to miss your source.

So that is something that needs to be considered by the analysts, and we have a whole section in the reg guide for Section 2.32 is elevated or stack releases and it's how you account for that. Now, our preferred method and our recommended method is to consider a ground level release for exactly that reason. You get a ground level release. Then as it moves down wind under what is likely to be, you know, the driving conditions or worst dispersion conditions, it's going to hit along the ground and stay along the ground.

MEMBER BIER: Yes, okay. I guess the question that I have, though, is whether you get also the same phenomenon laterally, like, as the plume goes around a building or whatever, you get a high concentration in an area that would have been predicted under a pure gaussian method to have a low concentration.

MR. QUINLAN: So ARCON does consider building wake, and that's actually one of the strengths of the code compared to PAVAN, which you can put in a function of building wake but it's not as advanced.

MEMBER BIER: But I guess the whole thing is kind of leading me to wonder whether what you think is conservative is always conservative in taking your kind of extreme percentiles of chi over q. If it puts you in that bottom stable condition, then it might not actually be conservative for all cases.

MR. QUINLAN: So, yes, I'm not sure I exactly understand the question. But, yes, building wake certainly plays into it. If your receptor is on the other side of the building and the plume has to go around the building --

MEMBER BIER: Right, yes.

MR. QUINLAN: -- then you do get some of that turbulence. It's going to mix out. It's going to affect the plume and make it less dispersed.

MEMBER BIER: Yes, I should probably just take a look at that chapter in the guidance.

MR. QUINLAN: Yes, absolutely.

MEMBER BIER: Thanks.

MR. QUINLAN: Of course. So some real world examples of atmospheric dispersion have been pulled. You know, there's, of course, plenty of examples out there. Here's one. I believe it's looking across the Delaware River at a fire at some kind of a refinery. But an example of an unstable plume. This looks to be at sunset when the atmosphere is beginning to transition from unstable to a stable on a clear day right now. So you still have a lot of dispersion through the atmosphere, so it comes up and it spreads out. You can kind of see how it's meandering.

Down here, a stable plume, no wind. I believe this is from England. But you can see on a day when there's no wind that that hot plume just goes straight up, it does not disperse until it hits some level where it's able to disperse. Now, picture having a light wind pushing that plume to the side and you can kind of get an idea of how -- now, this is from what looked to be an extremely tall stack, but picture a ground level release with a light wind pushing that plume in a single direction and you can kind of get a sense for how trapped into the ground that plume would become.

This was from an oil fire, I believe, in Nebraska. And an example of fumigation, which is discussed in a few of our reg guides, but really what it is is the plume being pushed one way and it gets trapped near the ground, and so all the plume near the ground gets mixed together. And so you end up with, you know, a pretty high concentration near the ground overall. So instead of the plume moving up as it is in the other examples, I believe this is right around sunrise, so the atmosphere is still extremely stable and that plume stays near the ground from a ground level source. For some reason, that always helps me picture it a little bit better.

And to completely beat a dead horse here, these are the Pasquill-Gifford stability classes A through G, G being extremely stable, and when there's a temperature difference of more than four degrees between the upper and lower measurements on the tower. So you've got an extremely stable atmosphere leading to higher concentrations.

Getting a little bit more into how we actually collect the data, the typical on-site meteorological measurement program, this comes out of Regulatory Guide 1.23. The primary tower on each site usually has, and, you know, each site could be a little bit different, but typically you have a 60-meter observation level for wind speed direction and temperature, a 10-meter level for wind speed direction and temperature, the delta temperature. The delta T that we use for stability is the measure between the two. And then you've got some other stuff that you measure, of course: dew point; solar radiation at some sites; precipitation is there, as well. There's usually a backup tower in case the primary tower fails or is out of service for some reason, and the sampling rates is usually once per second, but then that gets averaged over eventually to one hour value for that entire hour.

So how we actually use these codes in siting a design, there are two NRC models that get used for design basis accidents. There's the PAVAN, which has been traditionally used for EAB and LPZ. There's ARCON which has been used for control room habitability analyses.

So for the PAVAN code, it really comes out of the methods laid out in Regulatory Guide 1.145, Atmospheric Dispersion Models for Potential Accident Consequences Assessments. It is captured for the staff in SRP234, Short Term Atmospheric Dispersion

Estimates for Accident Releases. And then some of these supporting documents. There's the technical basis and the user's guide for PAVAN.

And PAVAN is a gaussian plume model that's used for ground level releases. It does not really consider elevated releasers because, again, it is meant to be quite conservative. Diffusion coefficients are modified to account for plume meander under low wind speed conditions and building wakes, although ARCON has a more advanced algorithm for building wake effects. It takes the chi over q values for various time average periods, so zero to two hours is really what gets used for the design basis accidents. And so what that means is that those are going to be your worst hours of dispersion; and so if you assume that there's a release for anywhere between zero to two hours, these are the ones that you would use. You can also assume an accident happens for zero to eight hours, 16 hours, three days, 26 days. Those are the periods that are used in accident analyses. And as you go out and you average out over a larger number of chi over q values, your estimates will decrease because you're averaging over a greater number of chi over q values instead of your most extreme.

One of the big difference between the codes is that PAVAN uses a joint frequency distribution, so you're really getting rid of your hourly data and you're concatenating into a big grid that consists of the wind speed classifications and calm winds; wind direction breaking into the 16 directions, so you're really removing the granularity of specific wind directions and you're breaking it down just to the compass directions; and then stability class stays the same, still based on delta T.

I don't think anything more needs to be said about that.

A little bit more on PAVAN. So we talked a couple of times about how you pull out specific chi over q values to represent the zero to two-hour time interval. There's the 0.5 percent maximum sector value or, read differently, 99.5 percent; the two terms are interchangeable. So that is for one specific sector, so that's looking in one direction. You can pull out that value, or you can compare it against the five percent overall. So consider all 16 compass directions, what is the 95-percent highest chi over q, how does it compare with one sector which has a more extreme value but you're discounting 15 out of

16 directions at that point. So whichever is higher is then used as the zero to two-hour chi over q value. Even though it is actually a one-hour value, you conservatively assume that it's for two.

And this procedure is repeated in PAVAN two times: once for the exclusionary boundary and once for the low population zone. Typically, there will be two rings around a site representing each of those different boundaries.

A little bit more about the 0.5 percent or, as used in the alternatively, the 99.5 percent. I just talked about it, but just for each of the 16 direction sectors, so it's not an overall site one, it's just for a specific direction. It's calculated in each sector, and then those are placed in order from the greatest to the smallest chi over q values, and then you create a curve out of those values and you pull out, you want to make sure that no other point are plotted above that curve. And from this upper curve, the chi over q value, which is equal or exceeded 0.5 percent of the time, so based on a normal year of data would be the 44th hour, 44th highest hour, is obtained. And that ends up being the chi over q value for the 99.5 percent maximum sector.

The five percent is a little bit simpler but follows the same type of ranking, same type of approach. But instead of one sector, you're looking at all of the sectors, so all of the wind directions. And for this, you would pull out the 99.5 percent chi over -- I'm sorry, the 95 percent or 5 percent, depending on how you want to look at it, you'd rank them, and you would then pull out that value, which is, again, a typical year at a 438th highest value out of that whole year.

Kind of an example of what that would actually look like when you take the chi over q values. The chi over q value is here on the Y axis and the percent frequency with respect to time here on the X axis. Now, this was just shown for two different wind speeds, 1 meter per second versus 0.5 meters per second. And if you want to pull out the ones that are circled are the 99.5 percent values for a sector. For the 1 meter per second, the values are, I don't have an exact value here, but they're down here. And then for the half meter per second, they're up here.

So the half meter per second, because it's a lower wind speed but it still concentrates the plum in a direction, and you end up with a bit of a higher chi over q value when you extrapolate out. Not every data set is actually going to calculate out that far.

So you can calculate for an entire year, so to calculate for a low population zone you maybe want longer values. So in order to get the zero to two hours, you calculate this, but you can also have an overall annual average chi over q, 8,760 hours, and you can calculate whatever time period you want in between. There are set ones in our guidance: again, zero to two hours; zero to eight hours; a 16-hour period, a three-day, and then a 26-day period. And so you basically do a linear interpretation between zero to two hour and the annual average to get your chi over q values.

I don't think I need to go too terribly deep into the definitions, but, since this guidance is focus and design basis accidents, we are concentrating on the exclusionary boundary, the area surrounding the reactor, and then the low population zone. The area immediately surrounding the exclusionary, which can contain residents but, typically, a small number of residents. And I'm just showing an example of what that can look like in actuality. So this was pulled from an early permit application that ended up not moving forward, but I thought it provided a good example of what an exclusionary area boundary can look like. And I thought it was actually even more helpful, this example, because it was a little more applicable to this guidance document that we're discussing today. But each direction, each of the compass directions, will have a distant out to the EAB. Some sites just do a concentric ring. It's the exact same distance to every area. This site happens to have slightly different values for different directions. And then the low population zone will consist of a ring beyond that.

So this is assuming a large light-water reactor placed at that site, so the value is a little bit far. But for a small modular reactor or an advanced reactor, maybe these are in 80 meters or, you know, closer, like 300 meters, I think, was an example that was actually used in real life. So you can see that they're much closer in, so that's why they would consider ARCON instead of PAVAN.

A little bit more about ARCON. Also, a gaussian plume model. The diffusion coefficients account for enhanced dispersion under low wind speed conditions and the building wakes, which we discussed at length already this morning. The big difference is that this uses hourly values. Instead of the joint frequency distribution, this uses hourly values of wind speed, wind direction, and atmospheric stability class. Most other portions of it are similar in how it's treated and how it's calculated. But you, again, can combine estimate concentrations ranging from two hours to 30 days.

Cumulative frequency distributions which will become important later on in the presentation are prepared from the chi over q values. And then ARCON calculates the chi over q values that are exceeded no more than five percent of the time for each averaging period, so the 95 percent chi over q values. The 99.5 percent requires some additional work, which we will get into.

Typically, ARCON, again, is used for control room habitability. So this is an example of the AP1000 and how the ARCON analysis was done for all the sites that used this design. You would have two receptors, one at the control room HVAC right here and one at the annex building access. And then you have eight different sources where you could have a release, and so you would calculate the source to receptor combinations for every single one. And so you really -- AP1000 required doing 16 different runs for ARCON, but you can calculate the direction and then run the met data, and each one would be slightly different because it's a slightly different wind direction, so it uses different wind direction windows. But I just want to show you an example of how you go about setting up an ARCON run.

MEMBER HALNON: Hey, Kevin, those are all ground level release sources?

MR. QUINLAN: They are considered ground level releases, but each of these will have a unique -- only because there are specific criteria for what is an elevated release. But so each of them are run as a ground level release, I think with the exception of -- well, no, they're all considered point sources, as well, with the exception of number eight here which is the containment shell and that's used as a diffuse area so kind of more of a cloud of radiation, if you will.

But, yes, they're all considered ground level, but you do put in, and I'll show you in a couple of slides, the input form. Each of these is going to have a height to it as a source and the receptor will also have its unique height. This one, I believe, is a door, so that would, more or less, three feet, it's assumed.

MEMBER HALNON: So the elevation is somewhat considered. Okay, I got it. Thanks.

MR. QUINLAN: Yes, absolutely. It is absolutely considered in this.

The applicable guidance for ARCON is also captured in SRP234. That's the same SRP section as PAVAN because both of them are considering short-term dispersed estimates for accident releases. The guidance is laid out at Reg Guide 1.194, and I'll be doing a comparison shortly between 1.194 and this guidance, not in-depth but enough to get kind of a flavor for it. And then there's the user's guide and the NUREG which describes the model in much more detail, NUREG/CR-6331.

So the relationship to the existing guidance between this reg guide that we're considering today. But, first, a comparison, a very high level comparison, between Reg Guide 1.194 for ARCON and Reg Guide 1.145 for PAVAN. The ARCON reg guide provides the guidance on determining chi over q values for control room habitability assessments, and Reg Guide 1.145 provides it for determining chi over q values at the EAB and the LPZ.

So in comparing Reg Guide 1.194 versus the current draft reg guide that we're discussing today, they're quite similar, similar in almost every single way except for how it's being used. So they both use hourly met data. The model setup is exactly the same. There's one source receptor pair, which is a distance and direction per run. It can use ground level or elevated release, and it can be modeled as either a point source or a diffuse source. So a point source, you know, picture something coming out of a pipe. Diffuse source, picture more of a cloud.

The model results coming out that are discussed in Reg Guide 1.194 are the typical ARCON results which considers the 95th percentile chi over q for each source receptor pair. The draft reg guide will certainly do that, but it also includes a method in its Appendix A of the reg guide for determining the maximum sector 99.5 percent chi over q. That is not a standard output of ARCON. It will take extra calculation for a licensee or an applicant to calculate.

So here is the ARCON input display, as promised a couple of times. So here you would enter your input, your direction to the source, so your receptor to the source, I'm sorry, your source to receptor direction. Here is just one degree, so it's basically due north. Your receptor distance, how far it would be. Your release height, so where is it coming out of. For ARCON, typically, out of some portion of the building and it's going into another portion of a different building likely. So you consider the two intake and release heights. A building area, so containment building typically will have, you know, it's a large building, you can use as diffuse source. You could put in how big the building is and any elevation differences. And the building area is the driver between the building for the building wake effect that ARCON considers. So we talked about that a couple of times this morning, but the building wake, that's really where this comes into play.

A couple of additional inputs. And I wanted to put this one up because the default is a 90-degree wind direction window, so whatever your wind direction is from your source or receptor, say it's due north, so zero degrees, this would consider a 90-degree window on either side of that source to receptor window or direction and it would pull all of the wind directions that fall into that 90-degree window. And that is what is considered for the chi over q value. If it's not blowing in that direction, then you really don't care because it's not going to be blowing towards your receptor.

So the default is a 90-degree window, and that comes from Reg Guide 1.194 for use in control and dispersions. Reg Guide 1.249, the one we're discussing today, recommends changing that to a 45-degree window because that is more consistent with the PAVAN guidance in Reg Guide 1.145. So we tried to do our best to keep the ARCON, how you set up the ARCON run the same. But since we're not considering control habitability, we're now considering off-site doses, we wanted to make sure that we were more inline with the off-site guidance that we've been using for a long time now. So that's why we recommend changing this to 45 degrees. It narrows the window a little bit for the off-site receptors.

And then a very high level comparison between the PAVAN Reg Guide 1.145 and this reg guide, so this should look very familiar from a few slides ago. But PAVAN uses joint frequency distribution. ARCON uses the hourly. The model setup is quite different. You run all 16 directions at the same time, and you can run multiple distances all at once versus ARCON which uses one source receptor pair and you really have to do them one at a time. The model results are complicated, but it does calculate both of these values, the 95 and the 99.5 percent chi over q at the same time, versus ARCON which only calculates the 95 percent and then you have to do a little bit of extra work for the 99.5.

So at this point, I'm going to turn this portion of the presentation over to Jason. I'll run the slides, so, Jason, just let me know when you want me to move the slide forward. But Jason will now take you into the expanded use of the ARCON code and a little bit more about the reg guide itself.

MR. WHITE: Yes. Thanks, Kevin. First, I want to check with Greg. Greg, how are we doing on time? Do we have a hard out? Because we have an example at the end of the presentation that we wanted to leave enough to discuss because it's kind of the heart of what we're trying to accomplish.

MEMBER HALNON: Yes, I would, I want to go to public comment at 11:15, so you have about, let's just say 20 minutes of presentation/discussion.

MR. WHITE: Okay. Well, I'll try to move through these slides quickly. Kevin did a great job of covering all the basics of the atmospheric dispersion analysis and these basics influence all the aspects of what we are presenting today. A lot of upcoming slides were touched upon earlier by Kevin, but, as I go through them, if there's any additional discussion, we can definitely delve into it again.

So in this section of the presentation, we will discuss the expanded use of the ARCON code, which is the basis for this draft Reg Guide 1.249.

MEMBER HALNON: Hey, Jason.

MR. WHITE: Yes.

MEMBER HALNON: Could you move the microphone just a little further away from your mouth. We're getting the puffing.

MR. WHITE: Oh, okay. I'm sorry.

MEMBER HALNON: Thanks. That sounds better.

MR. WHITE: Okay. How is that? Is that still loud enough but better?

MEMBER HALNON: Yes, that should be fine. We can adjust.

MR. WHITE: Okay. Because I could always adjust it more, if needed.

So the ARCON computer code was developed to model shorter distances in the vicinity of buildings typical of control room habitability evaluations. The ARCON dispersion algorithms are based on field measurements taken out to distances of 1200 meters. As stated before, large light-water nuclear power plants typically have EAB and LPZ distances that range from 800 to 6,000 meters, while small modular and advanced reactor designs are expected to include EAB and LPZ distances in the range of 80 to 400 meters.

Next slide. In this accident source term topical report, NuScale proposed using an ARCON computer code methodology for calculating off-site atmospheric dispersion values at the EAB and LPZ, rather than using the PAVAN computer code. This methodology deviated from NRC guidance. NuScale provided a justification for this use of this methodology and detailed why it was appropriate for its design.

During this review for the topical report, the NRC staff conducted an in-person audit of the topical report and the methodologies. The staff reviewed the documentation for how the methodology would be implemented and the staff also performed an independent analysis using the methodology.

Next slide. The NRC staff made the determination that the ARCON computer codes acceptable for modeling EAB and LPZ chi over q values at relatively short distances, as long as the methods are consistent with the regulatory positions of Reg Guide 1.145 for off-site chi over q values. Therefore, the methodology outlined in this draft Reg Guide 1.249 is applicable to the EAB and LPZ distances from source locations out to a distance of 1200 meters.

Next slide. In the next section of the presentation, we will discuss how the Reg Guide 1.249 will be used.

As was stated before earlier in the presentation, this draft reg guide is applicable to sites with EAB and LPZ distances out to 1200 meters. However, certain locations may be affected by transport and diffusion conditions that may be more restrictive than assumed in the contiguous 48 states. For these locations, which may be characterized by extreme and persistent restrictive dispersion conditions, such as in Alaska, the applicability of dispersion algorithms in ARCON may not apply or may require further modification.

Next slide. Some of the issues that may arise with the atmospheric dispersion analysis in these locations include different characteristics of accident releases, such as buoyancy and momentum, depending on ambient conditions at the time of the release. Also, transport and diffusion conditions possibly being significantly different or more restrictive than assumed. Seasonal variation of dispersion and meteorological conditions such that separate modeling approaches and models may be necessary at certain times of the year. These all could possibly lead to the need for field studies to characterize and model the dispersion conditions.

Next slide. Kevin went through the rationale on this topic earlier, but, due to the potential of the new or advanced reactor designs being considered in nontraditional locations, there may be a need to seek alternative meteorological sources at one or more of the licensing stages. An applicant may require off-site meteorological data in lieu of or in addition to on-site meteorological data from one or more reputable measurement locations.

As Kevin states, some of the examples of these alternate data sources include data from the National Weather Service stations, FAA stations, data from EPA-endorsed measurement programs, and U.S. Department of Defense or Department of Energy facilities.

MEMBER HALNON: Jason, this is Greg. Do you have any standards or expectations on what services or what data sources are acceptable? I mean, we've had one applicant use their state, you know, stuff, I guess, regional data. We've looked at the places --

MR. WHITE: Yes, we usually take a look at them on a case-by-case basis. And, you know, if you make a determination that it's a reputable source that has a decent history of quality control and, you know, we also do our own independent analysis of the data to check the quality, and if we decide that it's of good quality and appropriate for use, we'll usually accept it.

MEMBER HALNON: Okay. So a topic of pre-application discussions, I guess, would be more appropriate then, right?

MR. WHITE: Yes, yes, usually we have those discussions during the initial stages of contact with the applicants.

MEMBER HALNON: Okay, thanks. Go on.

MR. WHITE: No problem. Next slide, Kevin.

If the data from some of these alternate sources cannot be input directly into ARCON, the applicant will need to perform additional processing before the data can be used. Also, the applicant should identify each meteorological monitoring location to be used and the rationale for the selection. The applicant should then identify and explain any departures between the meteorological monitoring guidance used at each of the off-site locations and the monitoring guidance that's outlined in Reg Guide 1.23.

Next slide. As stated in regulatory position two of Reg Guide 1.145 and performed by PAVAN computer code, a 95 percentile overall site chi over q value or a 99.5 percentile chi over q value for each direction of sector should be determined for each analysis. In determining the bounding release receptor combinations, it will be necessary to consider the distance, direction, release mode, and height of the release locations to various EAB and LPZ receptor locations.

Next slide. This slide addresses a determination of the source receptor pair distances and directions. The figure shows an example of the limiting and non-limiting distances from buildings within the nuclear island to the EAB and LPZ boundaries.

Next slide. The figure depicts an example of how an applicant may use the building locations within the nuclear island area to determine a source receptor pair of the most limiting distance from the edge of the building to the EAB and LPZ. The preferred and most conservative method is to use the limiting distance from the nearest building edge and apply that distance over all 16 directional sectors and, thus, create a uniform circle around the nuclear island. Using a limiting distance over all 16 directional sectors would ensure that the most conservative chi over q value is calculated for each given sector.

Next slide. This figure shows the buildings within the nuclear island and each of the 16 directional sectors.

Next slide. The figure depicts an alternative method for determining the distance for each source receptor pair in each of the 22.5-degree sectors. This method uses the closest point of an applicable building in that sector to the EAB and LPZ. Using the closest point on an applicable building for each sector would create a less conservative but potentially more realistic set of chi over q values than the preferred method we just outlined.

Next slide. When determining the bounding release receptor combinations, the ARCON code provides release options that allow an analysis to monitor ground level releases, elevated releases, point source releases, and diffuse source releases. The draft reg guide includes positions that discuss the preferability of these release types and the limitations on each use, and I think Kevin touched on some of those before. The preferred method is usually the ground level point source release, which is the most conservative.

Next slide. This draft reg guide provides a method for applicants and licensees to use ARCON for off-site chi over q estimates. For each of the 16 downwind direction sectors, ARCON calculates the 95 percentile chi over q values for each source receptor combination, various time errors, periods from two hours to 30 days. As outlined in regulatory position two of Reg Guide 1.145, the user should also calculate the 99.5 percentile chi over q value for each sector and should select the larger of the two chi over q values. Add to the 99.5 percent maximum sector or the 95 percent overall site value to represent the chi over q values for the two hour interval.

Since ARCON does not calculate a maximum sector 99.5 percentile, as performed by PAVAN and stated in Reg Guide 1.145, this draft Reg Guide 1.249 describes a methodology the user can use to calculate that 99.5 percentile chi over q value for each sector.

Next slide. And now I'll turn it over to Kevin for an example of that methodology that we just discussed.

MR. QUINLAN: Thank you, Jason. So I said at the beginning of the presentation that I would apologize then and I'm going to apologize again that I'm going to talk about math on a Friday right before lunchtime. But we wanted to provide an example of how you go calculating the 99.5 percentile chi over q value from the ARCON output because this is really where the main differences come between the two codes, and it is certainly one of the important inputs and important methods that licensees have already used and will likely use in the future.

So ARCON produces standard output files that can be used to analyze the data and produce chi over q exceedance frequencies that are not typically calculated in ARCON runs. A standard output file includes a frequency file, which is an output file with the extension of a CFD, cumulative frequency distribution. And the file contains the cumulative frequency distributions of the concentrations calculated for ten different averaging intervals and is designed to be imported into a spreadsheet for further data analysis and display.

Please stop me if you have any questions, but I think anybody with a basic understanding of frequencies and linear interpolation, this should be fairly intuitive. There's really nothing terribly complicated about it.

This is an example of the output file. This is the cumulative frequency distribution file that ARCON will produce. This one is cut off here with a couple of ellipses just to save some space, but the very first column here is our chi over q values. These are not model output files. These are thresholds that the -- it's basically between the one-year average and the one-hour values. I believe it picks specific values, but these are threshold values, which we'll get into; I'll explain that.

The second column here represents a number of one-hour averaging intervals, so the number of hours in the file, the one-year data set in this case, that exceed this threshold value. So in this case, this value of 2.291 times ten to the negative third is exceeded eight times in a one-hour value.

The third column is the number of times that it is exceeded over a two-hour average, and you can go on down the line for your different time periods. So depending on what kind of release you want to model, you can choose your different time periods, you can choose your different thresholds, and so you can calculate for those different release types and different time periods.

The one-hour averaging interval should be used, as discussed previously, to drive the zero to two-hour chi over q value. So that's what our guidance calls for, but it does come from a one-hour average and this is consistent with regulatory positions 1.3 and 1.4 in Reg Guide 1.145. And it's also consistent with the ARCON guidance in NUREG/CR-6331. So the two codes that are now being used for off-site estimates are consistent with each other.

And then for most ground level release scenarios, the one-hour averaging interval is expected to be bounding. We talked about this when going through the general meteorology slides earlier.

So the example describes this, but I'll show you how it's done in practice. Taking this first column, these threshold values, as well as the one-hour values, and putting them into a spreadsheet. So these are the exact same values, these are the number of times they've been exceeded, and this is the percent of the time that's been exceeded. So this is just an Excel frequency file.

Once the columns are delimited, broken out to different columns, the exceedance frequencies can then be identified. So a new column can be created that provides the percentage of the time that a given chi over q is exceeded. So as I discussed earlier, I gave you an example of individual hours. Eight individual hours exceed this threshold value of 2.29 times ten to the negative third. It's exceeded 0.09 percent of the time. So 99.91 percent of the time this value is not exceeded.

So using the exact same file, this can be done by identifying the total number of hours in the log file, which is a separate file that output, but it tells you some of the higher-level statistics about it. So in this case, there were ten missing hours in the data file, so we're left with 8,750 hours of individual hours that can be used. So we use this equation, equation 1A from the document, from the reg guide. It is just a simple equation to calculate the percentage of times something is exceeded. So a total would be the number of total hours, 8,750, minus the number of hours in that averaging interval or exceeded, so, in this case, eight; and then you multiply it by 100 to turn it into a percentage, and then you end up with these values. So these would subtract the number of hours in this averaging interval column, B, for each chi over q threshold from the total number of hours, 8,750, divide by the total number of hours, multiply by 100, and then you end up with these frequencies right here.

As the chi over q values in the first column, A, get smaller, they go from greatest to smallest here, the chi over q becomes more likely to be exceeded in a defined wind direction window. So as discussed, we recommend a 45-degree window. The default ARCON does a 90-degree window, but it doesn't make a difference for this calculation.

Therefore, the number of hours above any given threshold equal or increases as the chi over q decreases. So for chi over q values associated with an average interval of, an internal value of zero, sorry, an interval value of zero, this indicates the chi over q is never exceeded; and, therefore, 100 percent of the chi over q values are below this threshold value.

Same equation as before, nothing changed. Equation 1A up here should be applied to each line of the CFD file until the exceedance frequency of each chi over q in the first column is identified. The 99.5 percent value will most likely, and we certainly hope so, most likely be between two different chi over q threshold values. So I apologize on this file. I should have had a column D here, which subtracts column C from 100. So you can kind of switch it.

In this case, the 99.5 percentile chi over q value is bounded by lines 19 and 20 here, 2.09 and 1.91. So if you take that 0.4457, subtract it from 100, you end up with a 99.55 percentile value. And if you take the next line and subtract it from 100, you end up with a 98.75 percentile value. So between those two chi over q values will be your 99.5 percentile value, and that's what we're trying to calculate here.

So only a couple of slides left, and the worst of it over; I promise. So using those two values that we just identified on the screen before, the threshold values, 2.09, times ten to the negative third, and 1.91 times ten to the negative third, a simple linear interpolation can be used to determine the 99.5 percentile chi over q with the following equation. I won't go through the horrible details here, but, basically, why is what we're trying to get here, the 99.5 percentile value, why one is the lesser of the two threshold values for chi over q's, why two is the bigger.

You can change X right here. Right now, for this example, it is 99.5 because that's what we're trying to get at. But you could change that to whatever value you're trying to get. Environmental reviews use a 50th percentile chi over q value because they're more concerned with a realistic release and a realistic analysis, instead of a design basis most conservative analysis that the safety review is concerned with. So it's two different ways of doing the same analysis, but X here can be changed for whatever value or whatever threshold you're looking to pull out. And then X-1 is the lesser of the exceedance frequencies, and then X-2 is the greater of the two exceedance frequencies.

So using the exact same equation with those same values, this is what it actually would look like. So we put a 99.5 here. We subtract out the chi over q's and try to get the difference between those two threshold values. We then take the difference between those exceedance frequencies, you run it through the math, and you end up with a chi over q value of 2.077 times ten to the negative third.

So when error-checking, I went back to check and said, all right, does this make physical sense, does this make, you know, sense overall in calculating this. And because this value here, 2.089 times ten to the negative third, is quite close to the

99.5 percentile value anyway, it's 99.55, you would expect the resulting chi over q to be quite close this one and much farther away from the 98.75, and it is. You can see they're very, very close to each other, so that give us some confidence that this example is working correctly. But it could certainly be modified for different time periods and for different threshold values.

And that wraps up the math for my portion. And if there are no questions on that, I will give it back to Jason for our final two or three slides, and then we can open it up to any public questions that may be out there.

MR. WHITE: All right. Thanks, Kevin. I think we addressed most of the next points during the course of the meeting, but I'll provide a summary as to why this guidance was needed and the benefits it will provide.

NRC regulatory guides provide approaches that the staff considers acceptable for meeting the regulatory requirements addressed by that specific guide. At the same time, an applicant has the flexibility to propose alternate approaches to the guidance, so long as it identifies any differences and demonstrates that the applicable regulatory requirements are still met.

NRC staff has received topical reports and license applications proposing the use of an alternate approach to calculate the off-site atmospheric dispersion values of the EAB and the LPZ by using the ARCON computer code.

Next slide. Without applicable guidance, the NRC will continue to require justification for the applicability of the alternate approach in each application and continue to review them on a case-by-case basis. This could lead to the following: additional staff time to conduct non-standardized reviews and increased number of clarifying questions and RAIs during the staff's review, increased levels of interaction between the staff and applicant during both the pre-application and application review periods, and also a more expensive and lengthy application review at additional cost to the applicant.

Next slide. Draft Reg Guide 1.249 describes and approach that is acceptable to the NRC staff to meet the NRC requirements for determining the chi over q values and support of modeling on-site releases to outside boundaries using the ARCON code. Draft Reg Guide 1.249 would enhance the efficiency and the effectiveness of the review process of licensing applications and topical reports by having the common guidance document as the technical basis for the use of the ARCON methodology.

Next slide. And this concludes our presentation this morning, and we will be happy to address any questions that you have. Thank you very much for your attention.

MEMBER HALNON: Thank you, Jason and Kevin. Very, very informative, incredibly valuable for us to get back on to this topic since we're seeing it in the background so much right now in the applications we're looking at.

Any members or consultants have any further questions or comments? Okay. Given that, I'm going to open up the line to any public comments. Again, recall that, if you're on the phone, star 6 will unmute you. If you're on Teams, you can unmute yourself and introduce yourself and affiliation, if appropriate. So at this time, any public comments?

Okay. Very good. I understand that there's no public comments. Again, Kevin and Jason, I appreciate your time and efforts in putting this together. The conversation was worthwhile; and, again, because we're seeing this so much in the background of our applications and a lot of diverse places, we appreciate the time and effort you put in to creating this presentation. And I believe this will live for a while on our website for the ACRS and background materials because it's useful to go back and take a look at, especially some of the simplified pictures that you provided us.

One last chance for any comments from any members or our consultants.

DR. SCHULTZ: Greg, just one comment. This is Steve Schultz. One comment since there were no comments from the public. When this went out for public comments, I just wanted to commend those that did provide comments to the staff. There were a number of substantial comments on the particulars of the reg guide and commenters focused in great detail in ways in which to make the guide clearer and more usable. So a lot of good work was done there by those reviewers, public reviewers.

And I'd also like to commend the staff for their response to those comments. It was clear that they were looked at thoroughly and the staff considered them carefully and made changes to the guide where it was appropriate. So it was a nice job in that review and response.

MEMBER HALNON: Thank you, Steve. Totally agree. When I read through the comments, I usually gauge a comment from whether or not I can understand the math behind it, and I didn't understand a lot of the math, so they must have been good comments. That works for me.

Thank you. Any other members?

MEMBER REMPE: This is Joy, and I didn't have a comment pertaining to this session, but I would like members to stay on for a few-minute discussion after you close the record off, Greg. I just didn't want people to hang up and not stay on.

MEMBER HALNON: Thank you, thank you, Joy. So, again, just to reiterate, if the members could stay on after I adjourn, I would appreciate it and Joy has a quick message for us.

Okay. At this point, then it's about 12 after 11 Eastern Time. I will adjourn this meeting, and I appreciate everybody's attendance and the good conversation. The meeting is adjourned.

(Whereupon, the above-entitled matter went off the record at 11:12 a.m.)

United States Nuclear Regulatory Commission
Protecting People and the Environment

Draft RG 1.249

Use of ARCON Methodology for Calculation of Accident-Related Offsite Atmospheric Dispersion Factors

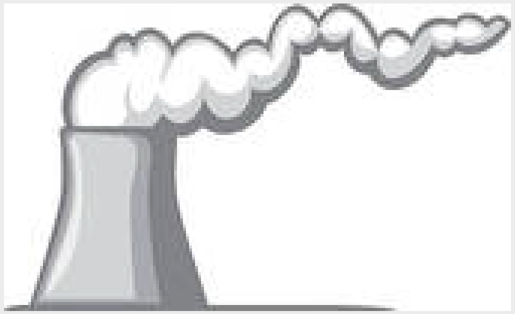
Presentation to ACRS

July 22, 2022

Outline

- Overview of Atmospheric Dispersion (χ/Q)
- Use in Siting and Design
- Current Guidance for χ/Qs at EAB/LPZ
- Relationship to other ATD RGs
- Expanded use of ARCON code
- How new RG will be used
- Example Calculation

Overview of Atmospheric Dispersion



Atmospheric Transport and Dispersion (ATD) Modeling

- Atmospheric Dispersion
  - Transport (Advection)
  - Diffusion
  - Removal
  - Transformation

χ/Q (sec/m^3) – "normalized" concentration factor

Concentration χ (Bq/m^3) divided by release rate Q (Bq/s)

D/Q (1/m^2) - "normalized" deposition factor

Deposition Rate D (Bq/m^{2}s) divided by release rate Q (Bq/s)

ATD Modeling

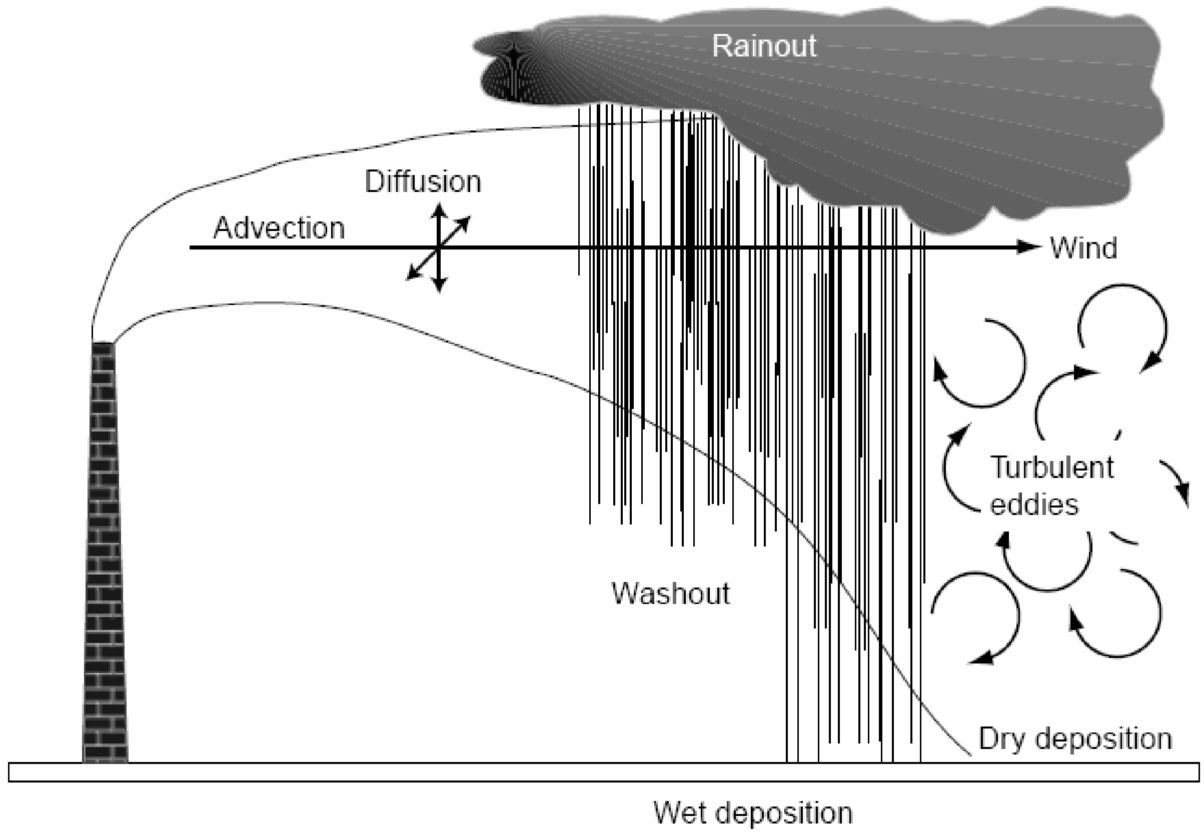


FIG. 3. The most important processes affecting the transport of radionuclides released to the atmosphere.

ATD Modeling

Onsite measurements

One year minimum

Transport with the wind (advection)

Diffusion caused by atmospheric turbulence

Thermal, mechanical

Important meteorological measurements for dispersion calculations

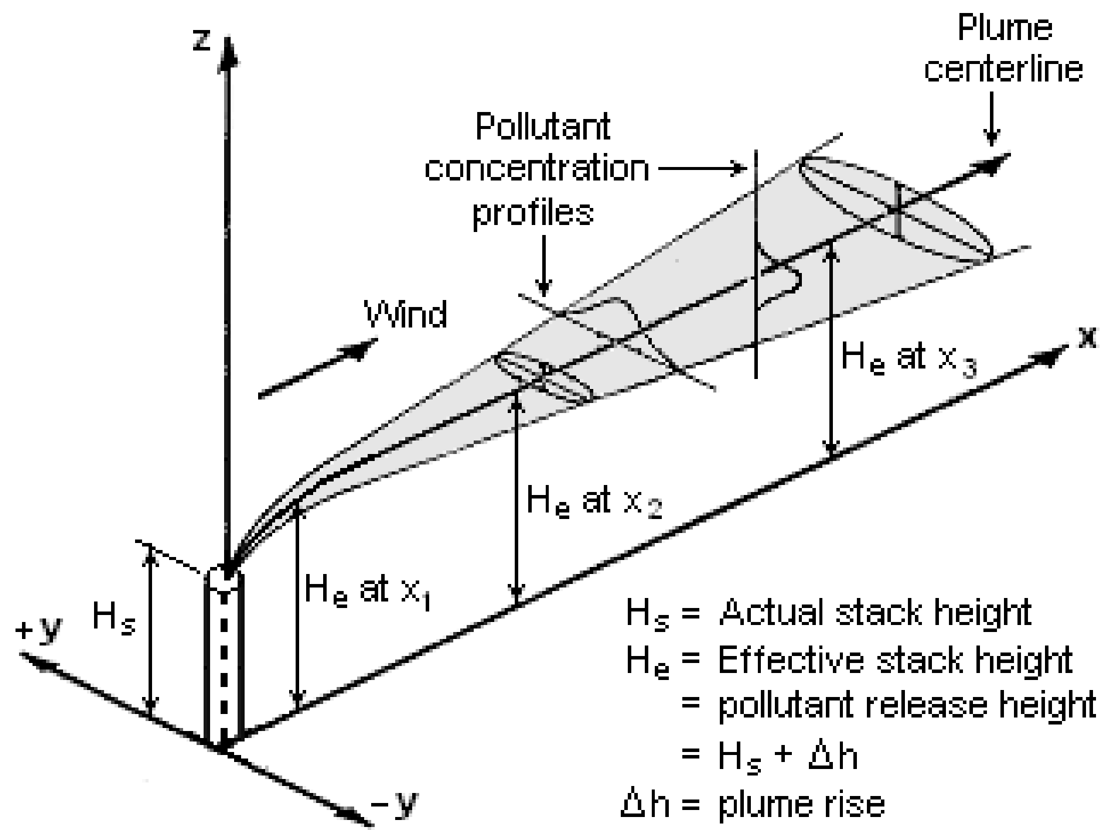
Wind direction	Wind speed	Atmospheric turbulence (stability)	Precipitation

Gaussian Plume Model

- Historically widely accepted in NRC radiological assessment activities associated with licensing
  - Fast
  - Only a few input parameters are necessary

- Assumptions
  - Emission rate is constant
  - Horizontal meteorological conditions are homogeneous over the space being modeled. For each hour modeled:
    - An average wind speed is used
    - Wind direction is constant (straight-line model)
    - Atmospheric turbulence (stability) is constant
  - No wind shear in the horizontal or vertical
  - Plume is infinite with no plume history
    - Each hour being modeled is independent of the previous hour
  - Dispersion in the crosswind (y direction) and vertical (z direction) has a Gaussian (normal) distribution
  - Diffusion is negligible in the downwind (x) direction

Gaussian Plume Model



Atmospheric Turbulence

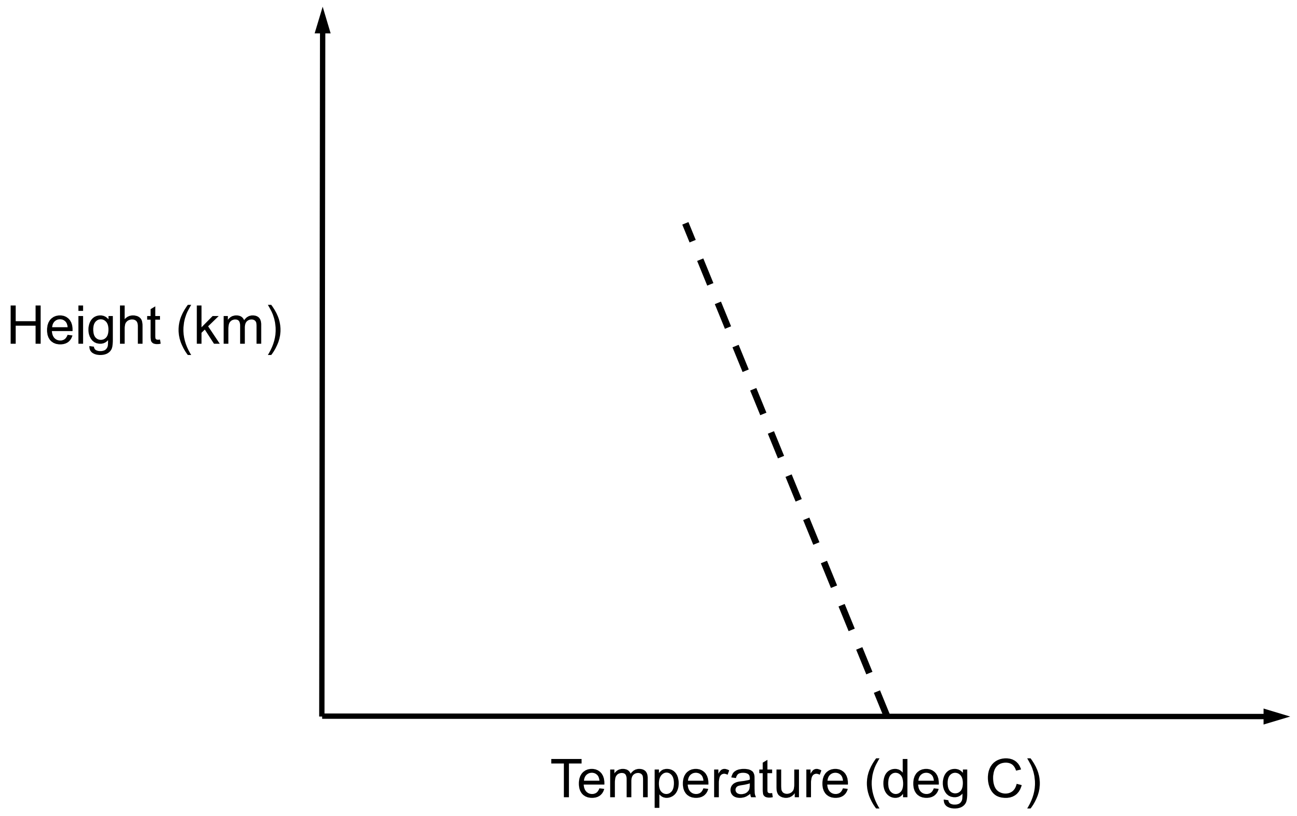
Causes

- Thermal (ground heating and cooling)
- Mechanical (surface roughness)

Measurement Methods

- Indirect Measurements
  - Wind speed (insulation method)
    - Solar radiation or sky cover during the day
    - Net radiation or sky cover at night
  - **Temperature lapse rate (delta-T)**
- Direct Measurements - some combination of:
  - Horizontal wind speed
  - Horizontal wind speed and/or wind direction fluctuations
  - Vertical wind speed and/or wind direction fluctuations

Atmospheric Turbulence



Atmospheric Turbulence

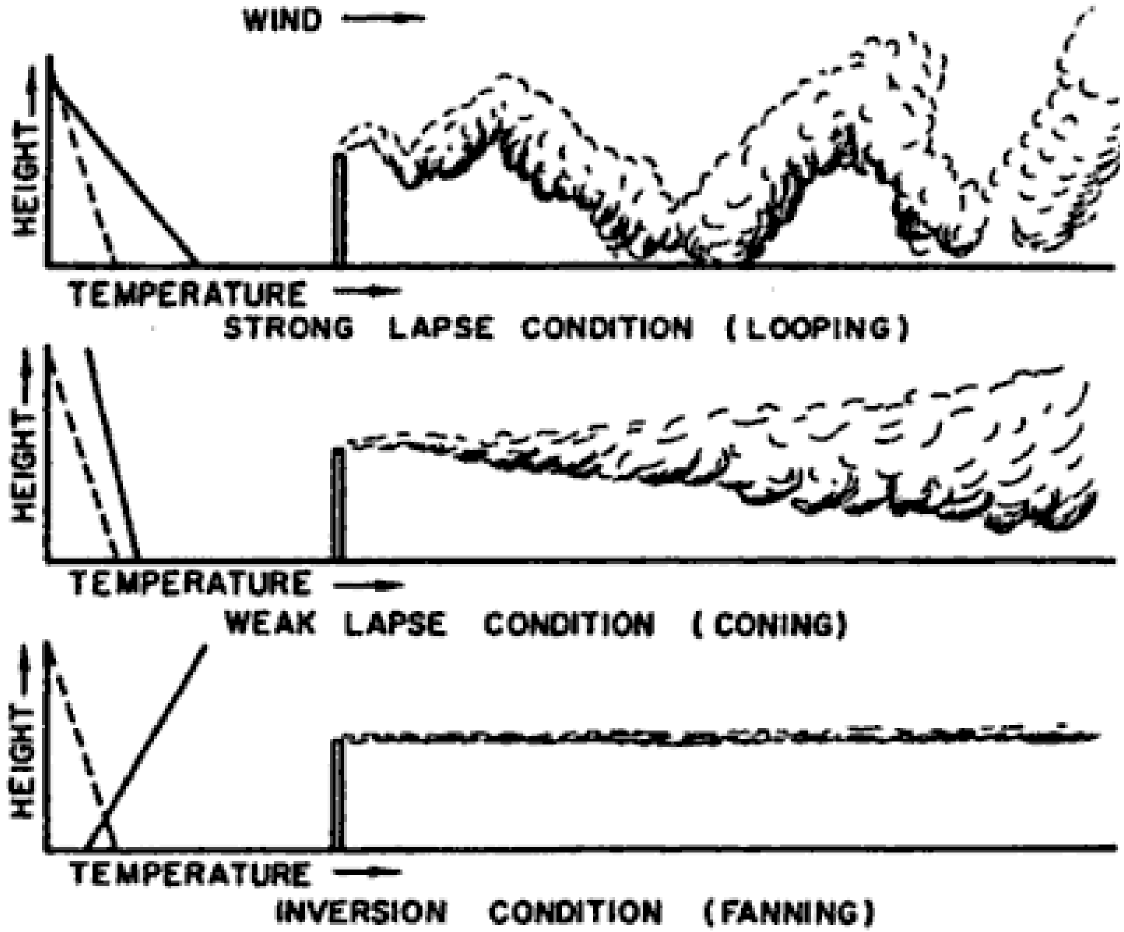
Atmospheric Condition	Typical Conditions	Heat Flux	Nature of Turbulence
Unstable (A, B, C)	Mid-Day Clear Sky Light Wind	Net Upward (Delta-T << 0)	Considerable Horizontal and Vertical
Neutral (D)	Windy or Cloudy or Transition	Zero (Delta-T < 0)	Mid-Range
Stable (E, F, G)	Nighttime Clear Sky Light Wind	Net Downward (Delta-T > 0)	Damps Out Vertical

Atmospheric Turbulence

Unstable
(A, B, C)

Neutral
(D)

Stable
(E, F, G)



Real world examples of atmospheric dispersion

Regulatory Guide 1.23

Classification of Atmospheric Stability

Stability Classification	Pasquill Stability Category	Ambient Temperature Change With Height (deg C/100m)
Extremely unstable	A	$\Delta T \leq -1.9$
Moderately unstable	B	$-1.9 < \Delta T \leq -1.7$
Slightly unstable	C	$-1.7 < \Delta T \leq -1.5$
Neutral	D	$-1.5 < \Delta T \leq -0.5$
Slightly stable	E	$-0.5 < \Delta T \leq 1.5$
Moderately stable	F	$1.5 < \Delta T \leq 4.0$
Extremely stable	G	$\Delta T > 4.0$

Typical Onsite Meteorological Monitoring Program

Primary tower

- **60-m: wind speed, wind direction, temperature**
- **10-m: wind speed, wind direction, temperature**
- **Between 60-m and 10m: delta-temperature**
- 3-m: dew point
- 2.5-m: solar radiation
- Ground-level: precipitation

Backup tower

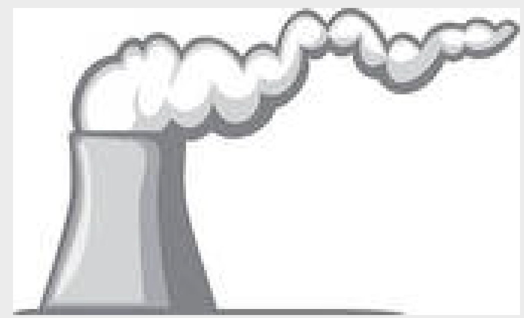
- 10-m: wind speed, wind direction, wind direction standard deviation, temperature

Sampling rate

- once per second

Use in Siting and Design

Current Guidance for EAB and LPZ



Atmospheric Dispersion

- Used in Siting, Licensing, and Design
- Two NRC models used for Design-Basis Accident (DBA) analysis
  - PAVAN (EAB / LPZ)
  - ARCON (Control Room)

DBA Releases to the EAB and LPZ

- Applicable NRC Guidance
  - SRP 2.3.4: *Short-Term Atmospheric Dispersion Estimates for Accident Releases*
  - RG 1.145: *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants (1983)*
  - NUREG/CR-2858: *PAVAN: An Atmospheric Dispersion Program for Evaluating Design-Basis Accident Releases of Radioactive Materials from Nuclear Power Stations (1982)*
  - NUREG/CR-2260: *Technical Basis for Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants" (1981)*

PAVAN Description

- Gaussian plume model
  - for ground-level releases, diffusion coefficients modified to account for plume meander under low wind speed conditions and building wakes
- Estimates χ/Q values for various time-averaged periods
  - 0-2 hrs, 0-8 hrs, 8-24 hrs, 1-4 days, 4-30 days
- Meteorological input consists of a joint frequency distribution (JFD) of hourly values of:
  - wind speed (calms defined as below sensor threshold, historically ~ 1 mph)
  - wind direction (16 directions, 22.5 deg sectors, centered on true north)
  - atmospheric stability class (preferably based on delta-T)
- Building wake impacts on release height
  - release points less than 2.5 times the height of adjacent solid structures → *ground-level releases*
  - release points more than 2.5 times the height of adjacent solid structures → *elevated (stack) releases*
- Part-Time fumigation conditions assumed for stack releases

PAVAN Description

- The larger of the following two calculated χ/Q values is selected to represent the χ/Q value for the 0–2 hour time interval.
  - <u>0.5-percent maximum sector value</u>
  - <u>5-percent overall site value</u>
- These calculated χ/Q values are based on 1-hour averaged data but are conservatively assumed to apply for 2 hours
- This procedure is repeated two times:
  - Once for the EAB
  - Once for the LPZ

PAVAN Description

<u>0.5-percent Maximum Sector χ/Q Value</u>

- For each of the 16 downwind direction sectors (N, NNE, NE, ENE, etc.), χ/Q values are calculated for each combination of wind speed and atmospheric stability at the appropriate downwind distance
- The χ/Q values calculated for each sector are then placed in order from the greatest to the smallest, and an associated cumulative frequency distribution is derived based on the frequency distribution of wind speed and stabilities for each sector.
- An *upper envelope curve* is determined for each sector, based on the derived data (plotted as χ/Q versus probability of being exceeded), so that no plotted point is above the curve
- From this upper envelope, the χ/Q value, which is equaled or exceeded 0.5 percent of the total time (44 hrs) is obtained
- The maximum 0.5 percent χ/Q value from the 16 sectors becomes the 0–2 hour "0.5- percent maximum sector χ/Q value"

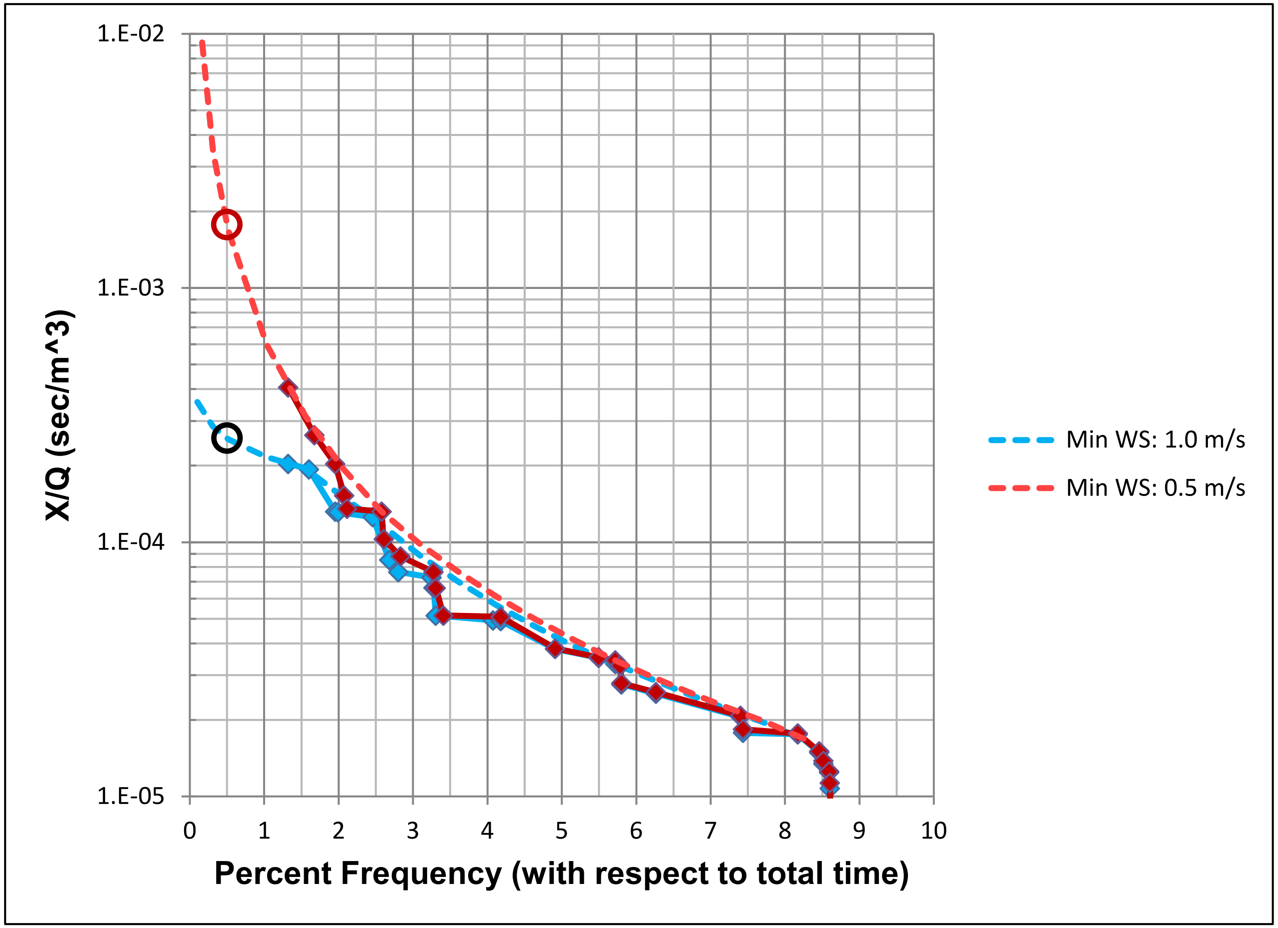
PAVAN Description

5-percent Overall Site X/Q Value

- Using the same approach, all χ/Q values independent of wind direction are combined into one cumulative frequency distribution for the entire site.
- An upper envelope curve is determined, and the χ/Q value that equals or exceeds 5.0 percent of the total time (438 hours) is selected

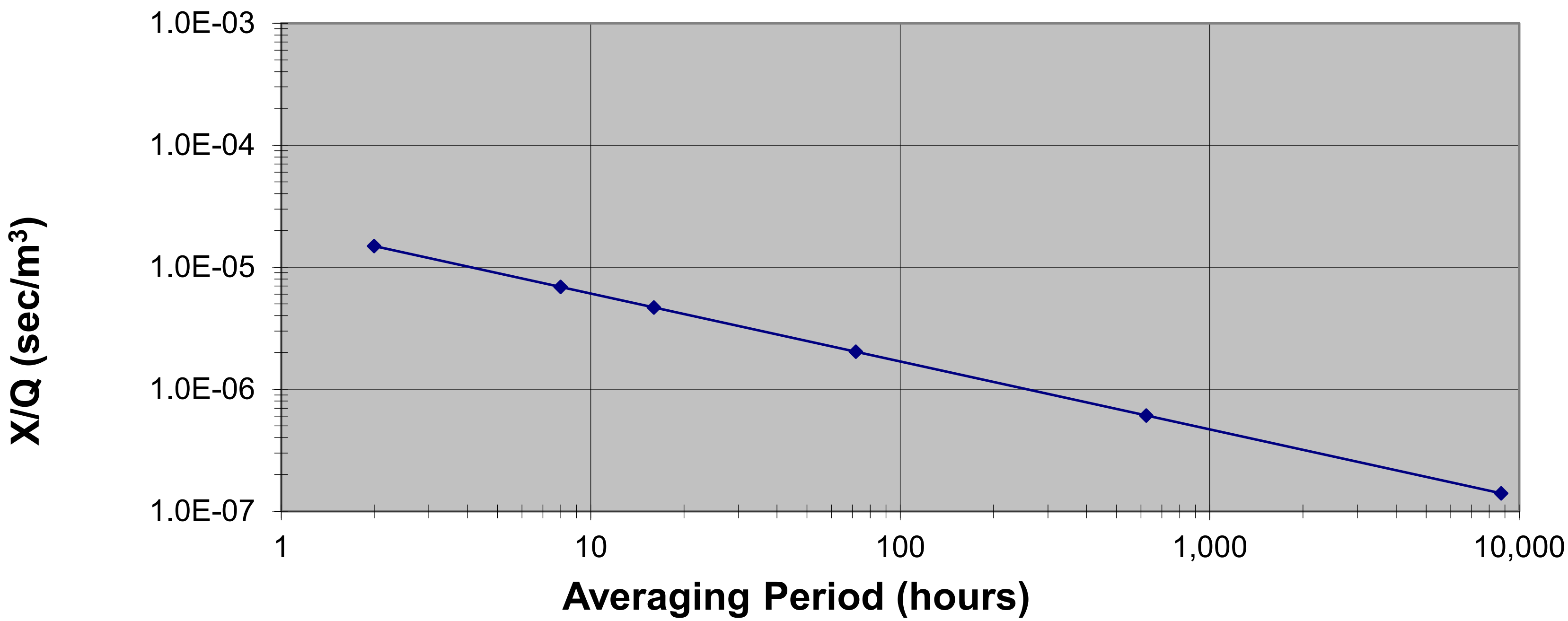
PAVAN Description

An upper envelope curve



PAVAN Description

To determine LPZ χ/Q values for longer time periods (e.g., 0–8 hours, 8–24 hours, 1-4 days, and 4–30 days), PAVAN performs a logarithmic interpolation between the 0-2 hour χ/Q values and the annual average (8,760 hours) χ/Q values for each of the 16 sectors and the overall site. For each time period, the highest among the 16-sector and overall site χ/Q values is identified and becomes the short-term site characteristic χ/Q value for that time period.



DBA Releases to the EAB and LPZ

- Definitions (10 CFR 50.2 and 10 CFR 100.3)
  - **Exclusion Area**
    - The area surrounding the reactor, in which the reactor licensee has the authority to determine all activities including exclusion or removal of personnel and property from the area …
  - **Low Population Zone**
    - The area immediately surrounding the exclusion area which contains residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident …

EAB

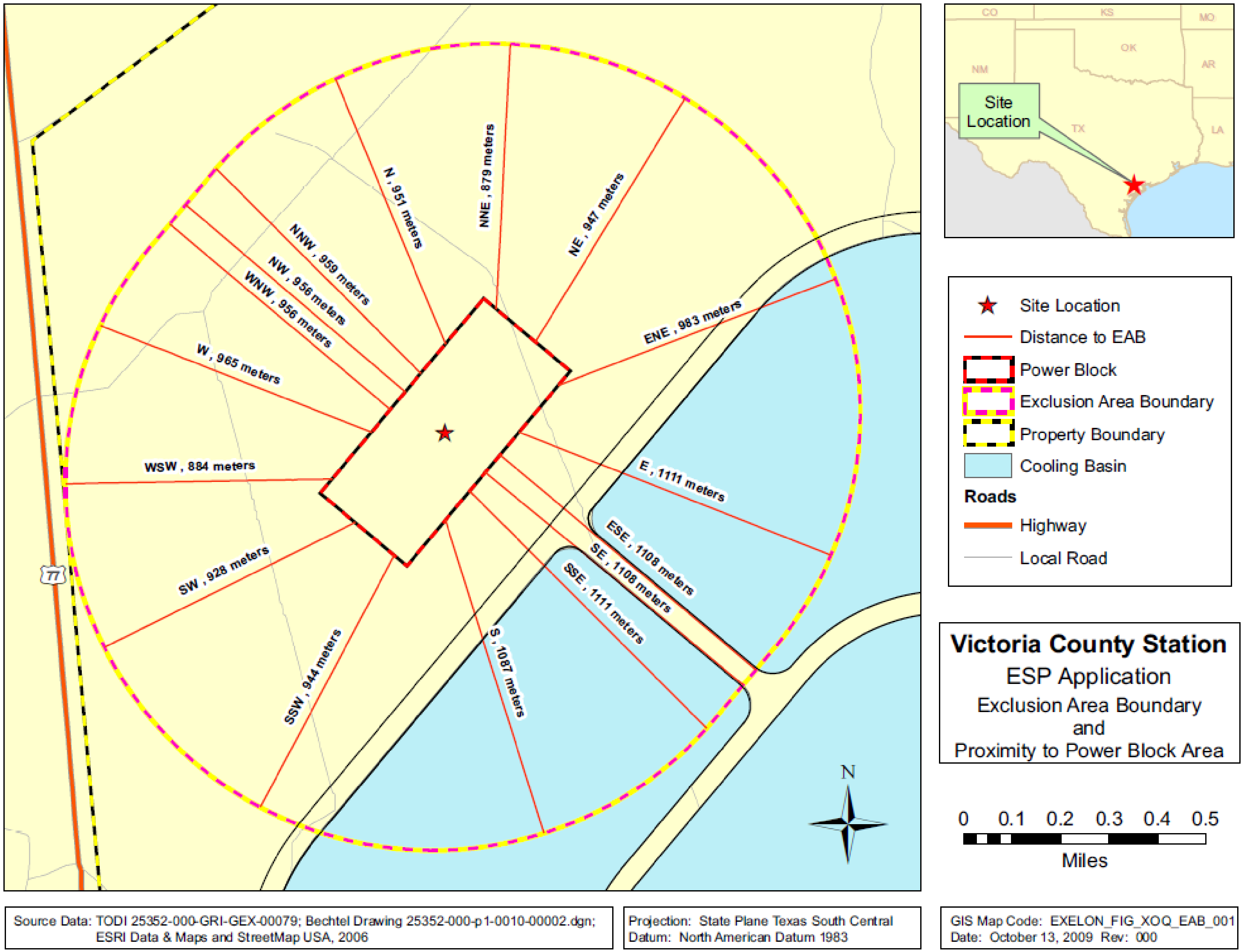


Figure 2.3.4-1 Distance to EAB from the Source Boundary

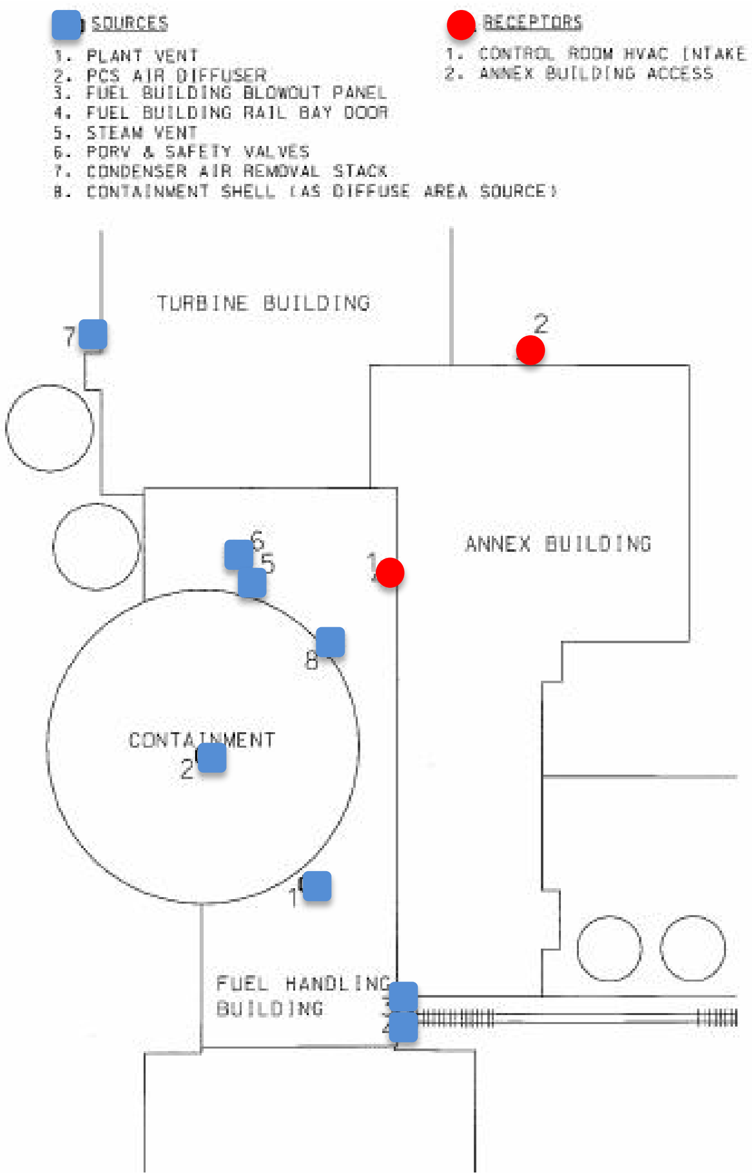
ARCON Description

- Gaussian plume model
  - diffusion coefficients account for enhanced dispersion under low wind speed conditions and in building wakes
- χ/Q values are estimated for various time-averaged periods
  - 0-2 hrs, 2-8 hrs, 8-24 hrs, 1-4 days, 4-30 days
- Meteorological input consists of hourly values of wind speed, wind direction, and atmospheric stability class
- Hourly meteorological data are used to calculate hourly χ/Q values
  - Hourly χ/Q values are then combined to estimate concentrations ranging in duration from 2 hours to 30 days
  - Cumulative frequency distributions are prepared from the average χ/Q values
  - χ/Q values that are exceeded no more than 5 percent of the time for each averaging period are selected

AP1000 DBA Release and Receptor Locations

- Receptors
  1. Control Room HVAC Intake
  2. Annex Building Access

- Sources
  1. Plant Vent
  2. PCS Air Diffuser
  3. Fuel Building Blowout Panel
  4. Fuel Building Rail Bay Door
  5. Steam Vent
  6. PORV & Safety Valves
  7. Condenser Air Removal Stack
  8. Containment Shell

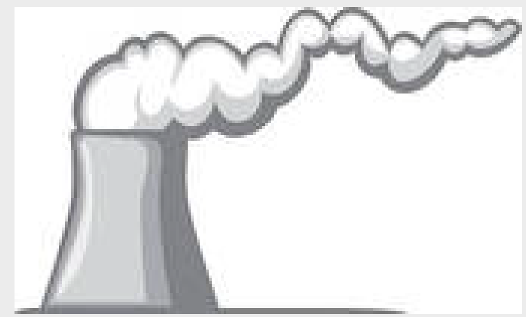


DBA Releases to the CR and TSC

- Applicable NRC Guidance
  - SRP 2.3.4: *Short-Term Atmospheric Dispersion Estimates for Accident Releases*
  - RG 1.194: *Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants (2003)*
  - NUREG/CR-6331: *Atmospheric Relative Concentrations in Building Wakes (1997)*
    - *ARCON96*

Draft RG 1.249

Relationship to Existing ATD Guidance



RG 1.194: Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants (2003)

Provides guidance on determining χ/Q values in support of design basis control room habitability assessments.

RG 1.145: Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants (1983)

Provides guidance on determining χ/Q values for DBA at the EAB and LPZ

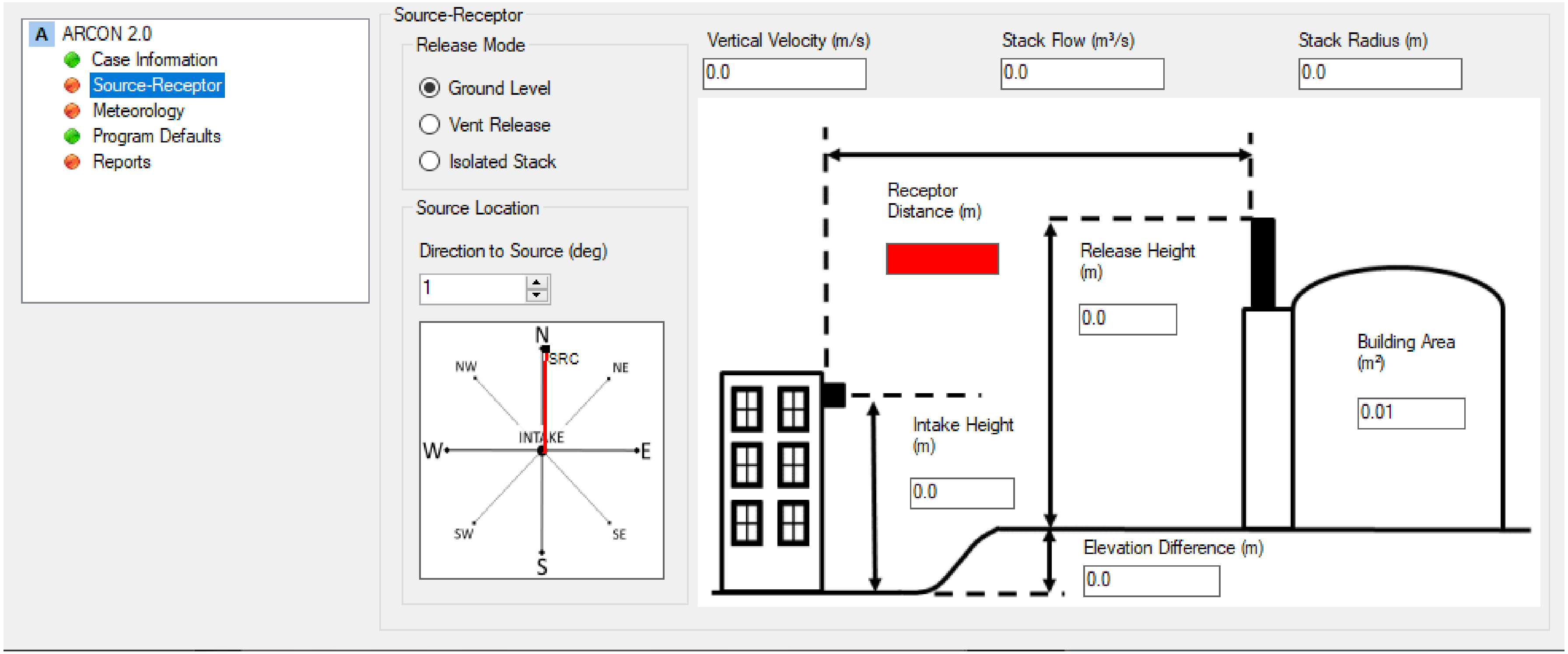
RG 1.194

- **Met Data Input**
  - Hourly Met Data
- **Model Setup**
  - One source-receptor (SR) pair (distance and direction) per run
  - Can use ground-level or elevated releases
  - Point or diffuse source
- **Model Results**
  - Determines the 95^{th}-percentile χ/Q for each SR pair

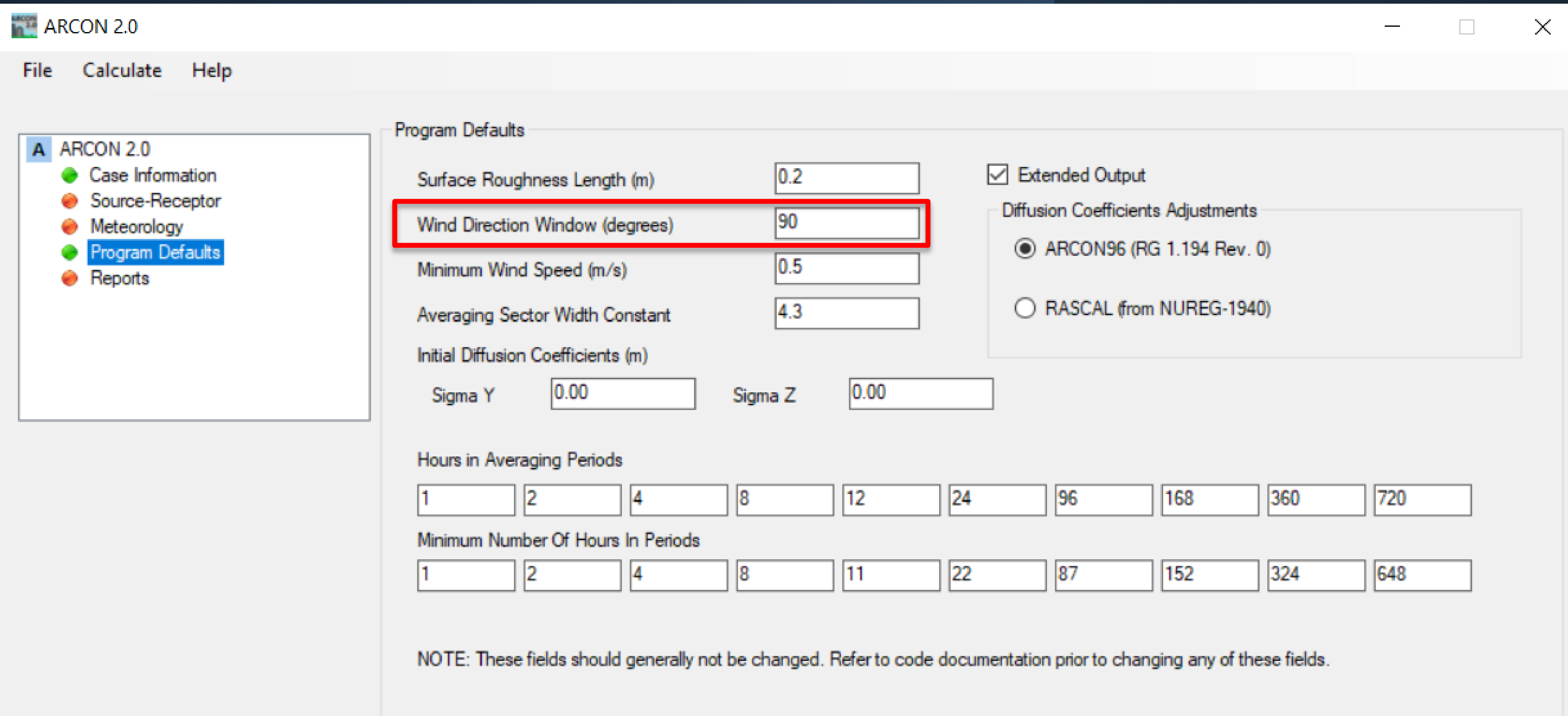
Draft RG 1.249

- **Met Data Input**
  - Hourly Met Data
- **Model Setup**
  - One source-receptor pair (distance and direction) per run
  - Can use ground-level or elevated releases
  - Point or diffuse source
- **Model Results**
  - Determines the 95^{th}-percentile χ/Q for each SR pair
  - Includes a method to determine maximum sector 99.5^{th}-percentile

ARCON Input Display



ARCON Input Display



ARCON default is 90-degree window, per RG 1.194 for use with control room dispersion.

RG 1.249 recommends changing to a 45-degree window for consistency with RG 1.145 for EAB / LPZ calculations.

RG 1.145 (PAVAN)

- **Met Data Input**
  - Joint Frequency Distribution
- **Model Setup**
  - 16 source directions at same time
  - Multiple distances at once
- **Model Results**
  - Larger of 95% overall or 99.5% χ/Q maximum sector value is selected for 0–2-hour timeframe.

Draft RG 1.249

- **Met Data Input**
  - Hourly Met Data
- **Model Setup**
  - One source-receptor pair (distance and direction) per run
  - Can use ground-level or elevated releases
  - Point or diffuse source
- **Model Results**
  - User can use either 95% χ/Q within 45-degree window or calculate the 99.5% χ/Q from within that same window

Expanded Use of ARCON Code

Expanded Use of ARCON Code

- The ARCON computer code was developed to model shorter distances in the vicinity of buildings typical of control room habitability evaluations.
- The ARCON dispersion algorithms are based on field measurements taken out to distances of 1,200 m.
- Large light-water nuclear power plants typically have EAB and LPZ distances that range from 800 to 6,000 m.
- Small modular and advanced reactor designs are expected to include EAB and LPZ distances in the range of 80 to 400 m.

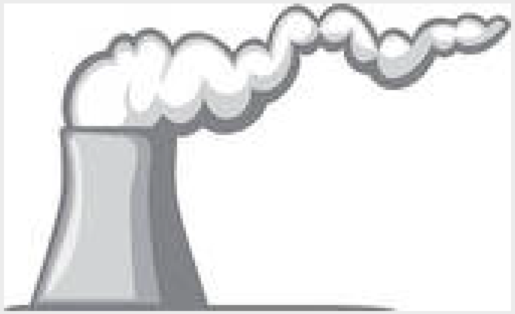
Expanded Use of ARCON Code

- In its Accident Source Term topical report NuScale proposed using the ARCON computer code methodology for calculating offsite atmospheric dispersion values at the EAB and LPZ rather than using the PAVAN computer code
- NRC staff conducted an audit of the topical report
- Staff reviewed the documentation for the methodology
- Staff performed an independent analysis using the methodology

Expanded Use of ARCON Code

- The NRC staff determined that the ARCON computer code is acceptable for modeling EAB and LPZ χ/Q values at relatively short distances as long as the methods are consistent with the Regulatory positions of RG 1.145 for offsite χ/Q values.
- Therefore, the methodology of draft RG 1.249 is applicable to EAB and LPZ distances from source locations within the nuclear island to a distance of 1,200 m.

How will RG 1.249 be Used?



Uses of Draft RG 1.249

Guidance on Locations

- Draft RG 1.249 is applicable to sites with EAB and LPZ distances from source locations out to a distance of 1,200 m.
- Certain locations are affected by atmospheric transport and diffusion conditions that may be more restrictive than assumed in the contiguous 48 states.
- For locations characterized by extreme and persistent restrictive dispersion conditions (e.g., in Alaska), the applicability of the dispersion algorithms in ARCON may not apply or may require further modification.

Uses of Draft RG 1.249

Guidance on Locations

The atmospheric dispersion analysis may be affected by deployment in certain locations. Issues include, but may not be limited to, the following:

- Different Characteristics of accident releases (e.g., buoyancy, momentum) depending on ambient conditions at the time of release
- Transport and diffusion conditions possibly being significantly different or more restrictive than assumed
- Seasonal variation of dispersion and meteorological conditions such that separate modeling approaches and models may be necessary at certain times of the year
- The possible need for field studies to characterize and model dispersion conditions

Uses of Draft RG 1.249

Guidance on Alternative Meteorological Data

Due to the potential of new or advanced reactor designs being considered in nontraditional locations there may be a need to seek alternative meteorological sources at one or more of the licensing stages.

- An applicant may acquire offsite (in lieu of, or in addition to, onsite) meteorological data from one or more reputable measurement locations.
- Examples include data from National Weather Service (NWS) stations, Federal Aviation Administration stations, U.S. Environmental Protection Agency (EPA)-endorsed measurement programs, U.S. Department of Defense or U.S. Department of Energy facilities, etc.

Uses of Draft RG 1.249

Guidance on Alternative Meteorological Data

- If these data cannot be input directly into ARCON, the applicant will need to perform additional processing before the data can be used.
- The applicant should identify each offsite meteorological monitoring location to be used and the rationale for the selection.
- The applicant should identify and explain any departures between the meteorological monitoring guidance used at each offsite location and the monitoring guidance in RG 1.23.

Uses of Draft RG 1.249

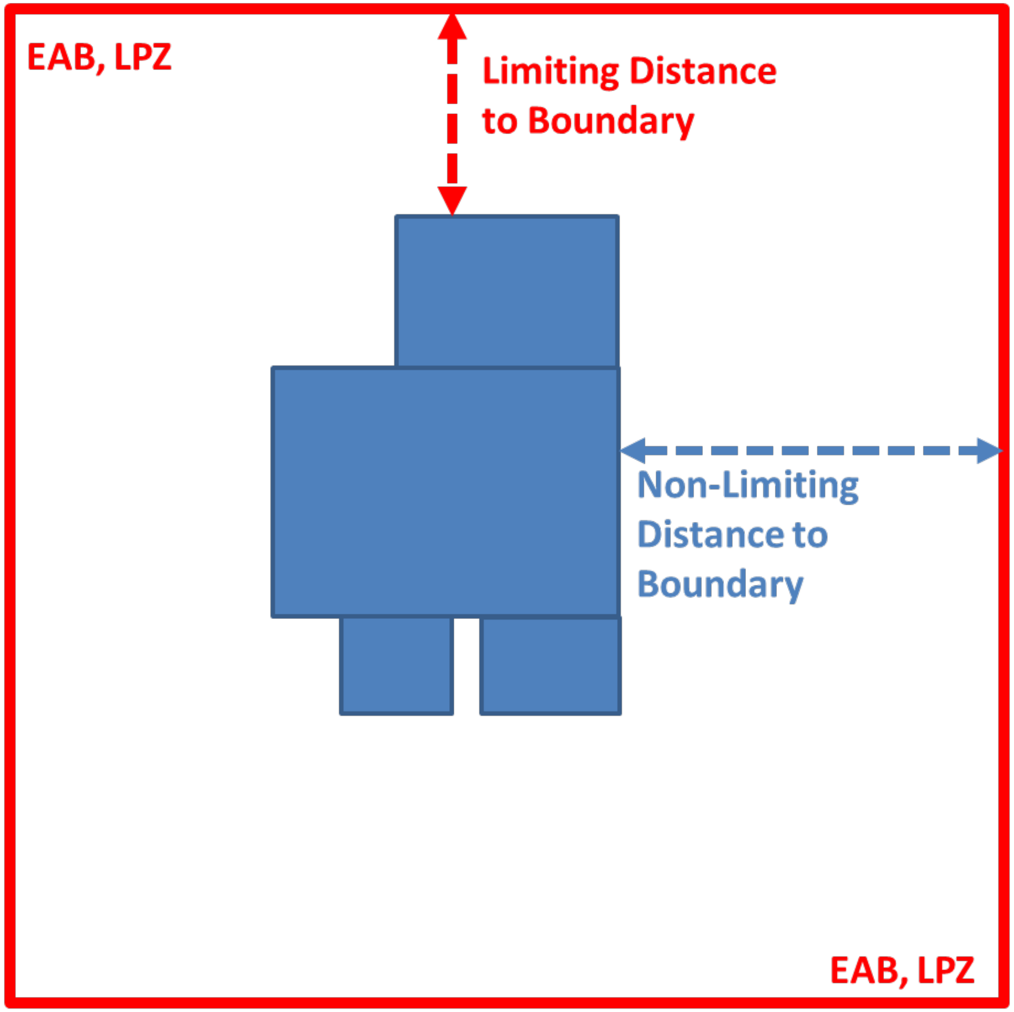
Release Characteristics

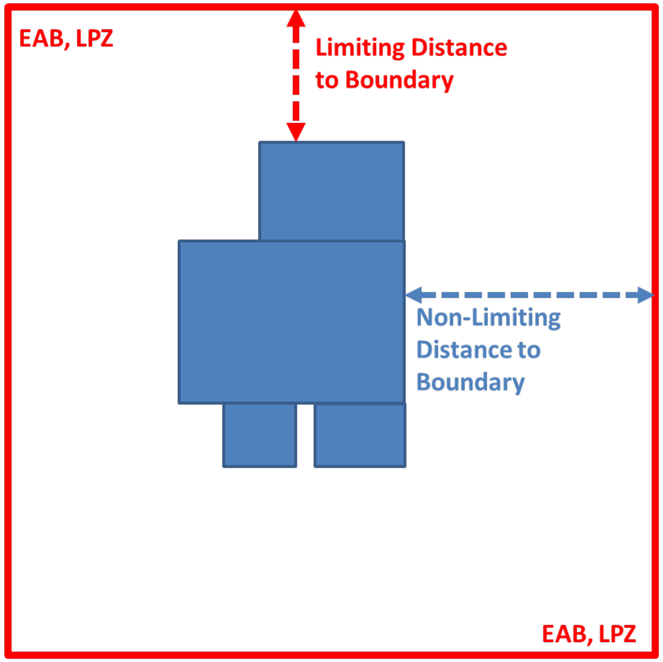
- As stated in Regulatory Position 2 of RG 1.145 and performed by the PAVAN computer code, a 95th-percentile overall site χ/Q value, or a 99.5th-percentile χ/Q value for each directional sector should be determined for each analysis.
- In determining the bounding release-receptor combinations, it will be necessary to consider the distance, direction, release mode, and height of the release location(s) to the various EAB and LPZ receptor locations.

Uses of Draft RG 1.249

Source-Receptor Pair Distances and Directions

- Figure shows an example of the limiting and nonlimiting distances from buildings within the nuclear island to the EAB/LPZ boundaries





- The figure depicts an example of how an applicant may use the building locations within the nuclear island area to determine a source-receptor pair of the most limiting distance from the edge of the building to the EAB/LPZ.

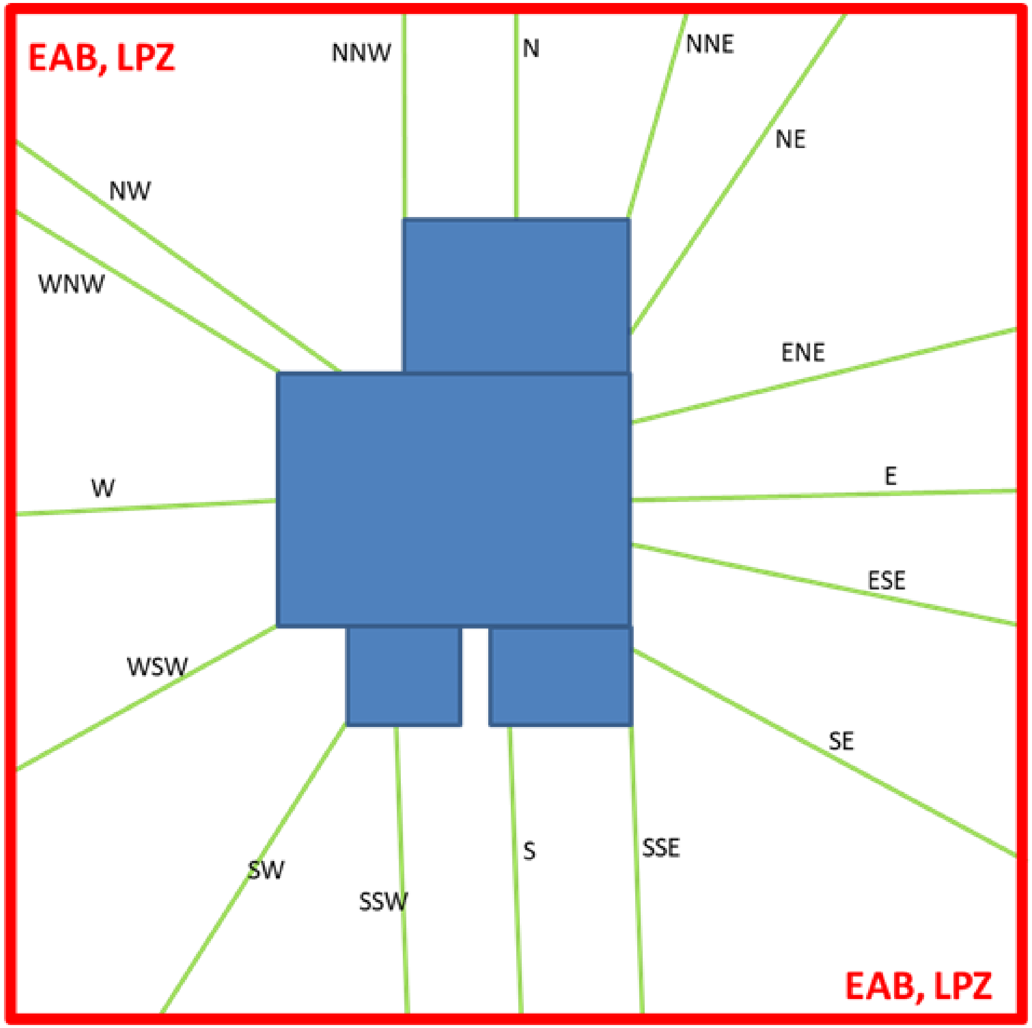
- The preferred, and most conservative, method is to use the limiting distance from the nearest building edge and apply that distance over all 16 sectors, thus creating a uniform circle around the nuclear island.

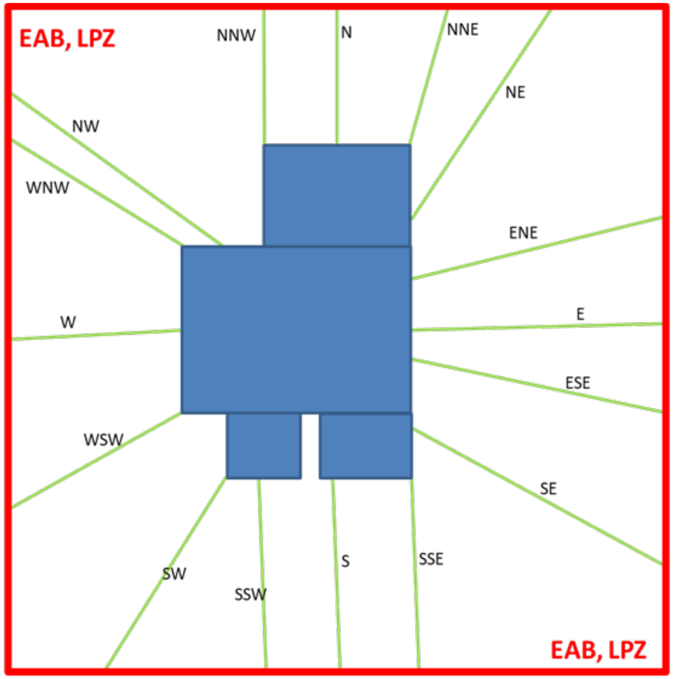
- Using the limiting distance over all 16 directional sectors would ensure that the most conservative χ/Q value is calculated for each given sector.

Uses of Draft RG 1.249

Source-Receptor Pair Distances and Directions

- Figure shows the buildings within the nuclear island and each of the 16 directional sectors





- This figure depicts the alternative method for determining the distance for each source-receptor pair in each 22.5-degree sector. This method uses the closest point of an applicable building in that sector to the EAB/LPZ.

- Using the closest point on an applicable building for each sector would create a less conservative but potentially more realistic set of χ/Q values than the preferred method.

Uses of Draft RG 1.249

Release Characteristics

- The ARCON code provides release options that allow an analyst to model:
  -Ground-level releases
  -Elevated (stack) releases
  -Point source releases
  -Diffuse Source

- The draft RG includes positions that discuss the preferability of these release types and limitations on their use.

Uses of Draft RG 1.249

Determining the 95th-Percentile and 99.5th-Percentile χ/Q Values

- This Draft RG provides a method for applicants and licensees to use ARCON for offsite χ/Q estimates. For each of the 16 downwind direction sectors (e.g., N, NNE, NE, ENE), ARCON calculates the 95th-percentile χ/Q values for each source-receptor combination for various time-averaged periods ranging from 2 hours to 30 days.

- As outlined in Regulatory Position 2 of RG 1.145. the user should calculate the 99.5th-percentile χ/Q value for each sector and should select the larger of the two χ/Q values, either the 99.5-percent maximum sector value or the 95-percent overall site value, to represent the χ/Q value for the 0–2-hour time interval.

- Since ARCON does not calculate a maximum sector 99.5th percentile, as performed by PAVAN and stated in Regulatory Position 2 of RG 1.145, draft RG 1.249 describes a methodology the user can use to calculate the 99.5th-percentile χ/Q value for each sector.

Example Process for Calculating 99.5th-Percentile χ/Q

- ARCON produces standard output files that can be used to analyze the data and produce χ/Q exceedance frequencies not calculated in typical ARCON runs.
- The standard output files include a "Frequency File" output file with the extension ".CFD" (cumulative frequency distribution).
- The .CFD file contains the cumulative frequency distributions of the concentrations calculated for 10 averaging intervals and is designed to be imported into a spreadsheet for further data analysis and display.

Example Process for Calculating 99.5th-Percentile χ/Q

X/Q CUMULATIVE FREQUENCY DISTRIBUTIONS

XOQ	1	2	4	8	XOQ	12	24	96	168	360	720
Abv. Lim.	0.	0.	0.	0.	Abv. Lim.	0.	0.	0.	0.	0.	0.
9.120E-03	0.	0.	0.	0.	9.120E-03	0.	0.	0.	0.	0.	0.
...											
2.754E-03	0.	0.	0.	0.	2.754E-03	0.	0.	0.	0.	0.	0.
2.512E-03	0.	0.	0.	0.	2.512E-03	0.	0.	0.	0.	0.	0.
2.291E-03	8.	2.	0.	0.	2.291E-03	0.	0.	0.	0.	0.	0.
2.089E-03	39.	14.	4.	0.	2.089E-03	0.	0.	0.	0.	0.	0.
1.905E-03	109.	60.	26.	10.	1.905E-03	0.	0.	0.	0.	0.	0.
1.738E-03	186.	130.	81.	53.	1.738E-03	0.	0.	0.	0.	0.	0.
1.585E-03	290.	211.	142.	90.	1.585E-03	18.	0.	0.	0.	0.	0.
1.445E-03	421.	294.	217.	154.	1.445E-03	42.	0.	0.	0.	0.	0.
1.318E-03	594.	432.	340.	226.	1.318E-03	81.	1.	0.	0.	0.	0.
1.202E-03	767.	570.	473.	339.	1.202E-03	136.	10.	0.	0.	0.	0.
1.096E-03	962.	721.	598.	497.	1.096E-03	211.	29.	0.	0.	0.	0.
1.000E-03	1087.	897.	758.	677.	1.000E-03	332.	55.	0.	0.	0.	0.
9.120E-04	1324.	1123.	1005.	901.	9.120E-04	490.	115.	0.	0.	0.	0.
8.318E-04	1464.	1309.	1259.	1203.	8.318E-04	701.	186.	0.	0.	0.	0.
7.586E-04	4635.	3946.	3232.	2456.	7.586E-04	961.	323.	0.	0.	0.	0.
6.918E-04	4645.	4026.	3397.	3170.	6.918E-04	1364.	501.	0.	0.	0.	0.
6.310E-04	4663.	4082.	3542.	3435.	6.310E-04	2242.	748.	17.	0.	0.	0.
5.754E-04	4663.	4194.	4383.	4003.	5.754E-04	2911.	1103.	49.	8.	0.	0.
5.248E-04	4663.	4277.	4467.	4171.	5.248E-04	3512.	1657.	250.	54.	0.	0.
4.786E-04	4663.	4352.	4585.	4685.	4.786E-04	3982.	2386.	494.	182.	0.	0.
4.365E-04	4663.	4472.	4711.	4814.	4.365E-04	4368.	3088.	843.	383.	63.	0.
3.981E-04	4663.	4963.	5020.	5140.	3.981E-04	4722.	3749.	1472.	917.	364.	0.
3.631E-04	4663.	5543.	5451.	5433.	3.631E-04	5029.	4408.	2672.	1661.	669.	419.
3.311E-04	4663.	5557.	5483.	5525.	3.311E-04	5347.	4954.	3848.	3104.	2211.	1344.
3.020E-04	4663.	5557.	5537.	5635.	3.020E-04	5611.	5488.	4894.	4638.	4096.	4495.
2.754E-04	4663.	5557.	5600.	6051.	2.754E-04	5822.	5904.	5829.	5702.	5757.	6000.
2.512E-04	4663.	5557.	5630.	6122.	2.512E-04	6065.	6233.	6487.	6652.	7127.	7297.
2.291E-04	4663.	5557.	5694.	6204.	2.291E-04	6256.	6501.	6984.	7363.	7838.	7867.
2.089E-04	4663.	5557.	5759.	6288.	2.089E-04	6442.	6699.	7334.	7750.	8135.	8035.
1.905E-04	4663.	5557.	6403.	6697.	1.905E-04	6636.	6915.	7644.	7949.	8245.	8112.
1.738E-04	4663.	5557.	6413.	6735.	1.738E-04	6766.	7079.	7900.	8127.	8386.	8112.
1.585E-04	4663.	5557.	6423.	6751.	1.585E-04	6866.	7217.	8082.	8284.	8436.	8112.
...											
1.000E-06	4663.	5557.	6423.	7373.	1.000E-06	7922.	8425.	8673.	8608.	8436.	8112.
Belw. Lim.	0.	0.	0.	0.	Belw. Lim.	0.	0.	0.	0.	0.	0.

- The second column represents the number of 1-hour averaging intervals that are exceeded by the X/Q thresholds provided in the first column
- The third column (with a header of "2") represents the number of 2-hour averaging intervals that are exceeded by the χ/Q thresholds.

Example Process for Calculating 99.5th-Percentile χ/Q

X/Q CUMULATIVE FREQUENCY DISTRIBUTIONS

XOQ	1	2	4	8	XOQ	12	24	96	168	360	720
Abv. Lim.	0.	0.	0.	0.	Abv. Lim.	0.	0.	0.	0.	0.	0.
9.120E-03	0.	0.	0.	0.	9.120E-03	0.	0.	0.	0.	0.	0.
...											
2.754E-03	0.	0.	0.	0.	2.754E-03	0.	0.	0.	0.	0.	0.
2.512E-03	0.	0.	0.	0.	2.512E-03	0.	0.	0.	0.	0.	0.
2.291E-03	8.	2.	0.	0.	2.291E-03	0.	0.	0.	0.	0.	0.
2.089E-03	39.	14.	4.	0.	2.089E-03	0.	0.	0.	0.	0.	0.
1.905E-03	109.	60.	26.	10.	1.905E-03	0.	0.	0.	0.	0.	0.
1.738E-03	186.	130.	81.	53.	1.738E-03	0.	0.	0.	0.	0.	0.
1.585E-03	290.	211.	142.	90.	1.585E-03	18.	0.	0.	0.	0.	0.
1.445E-03	421.	294.	217.	154.	1.445E-03	42.	0.	0.	0.	0.	0.
1.318E-03	594.	432.	340.	226.	1.318E-03	81.	1.	0.	0.	0.	0.
1.202E-03	767.	570.	473.	339.	1.202E-03	136.	10.	0.	0.	0.	0.
1.096E-03	962.	721.	598.	497.	1.096E-03	211.	29.	0.	0.	0.	0.
1.000E-03	1087.	897.	758.	677.	1.000E-03	332.	55.	0.	0.	0.	0.
9.120E-04	1324.	1123.	1005.	901.	9.120E-04	490.	115.	0.	0.	0.	0.
8.318E-04	1464.	1309.	1259.	1203.	8.318E-04	701.	186.	0.	0.	0.	0.
7.586E-04	4635.	3946.	3232.	2456.	7.586E-04	961.	323.	0.	0.	0.	0.
6.918E-04	4645.	4026.	3397.	3170.	6.918E-04	1364.	501.	0.	0.	0.	0.
6.310E-04	4663.	4082.	3542.	3435.	6.310E-04	2242.	748.	17.	0.	0.	0.
5.754E-04	4663.	4194.	4383.	4003.	5.754E-04	2911.	1103.	49.	8.	0.	0.
5.248E-04	4663.	4277.	4467.	4171.	5.248E-04	3512.	1657.	250.	54.	0.	0.
4.786E-04	4663.	4352.	4585.	4685.	4.786E-04	3982.	2386.	494.	182.	0.	0.
4.365E-04	4663.	4472.	4711.	4814.	4.365E-04	4368.	3088.	843.	383.	63.	0.
3.981E-04	4663.	4963.	5020.	5140.	3.981E-04	4722.	3749.	1472.	917.	364.	0.
3.631E-04	4663.	5543.	5451.	5433.	3.631E-04	5029.	4408.	2672.	1661.	669.	419.
3.311E-04	4663.	5557.	5483.	5525.	3.311E-04	5347.	4954.	3848.	3104.	2211.	1344.
3.020E-04	4663.	5557.	5537.	5635.	3.020E-04	5611.	5488.	4894.	4638.	4096.	4495.
2.754E-04	4663.	5557.	5600.	6051.	2.754E-04	5822.	5904.	5829.	5702.	5757.	6000.
2.512E-04	4663.	5557.	5630.	6122.	2.512E-04	6065.	6233.	6487.	6652.	7127.	7297.
2.291E-04	4663.	5557.	5694.	6204.	2.291E-04	6256.	6501.	6984.	7363.	7838.	7867.
2.089E-04	4663.	5557.	5759.	6288.	2.089E-04	6442.	6699.	7334.	7750.	8135.	8035.
1.905E-04	4663.	5557.	6403.	6697.	1.905E-04	6636.	6915.	7644.	7949.	8245.	8112.
1.738E-04	4663.	5557.	6413.	6735.	1.738E-04	6766.	7079.	7900.	8127.	8386.	8112.
1.585E-04	4663.	5557.	6423.	6751.	1.585E-04	6866.	7217.	8082.	8284.	8436.	8112.
...											
1.000E-06	4663.	5557.	6423.	7373.	1.000E-06	7922.	8425.	8673.	8608.	8436.	8112.
Belw. Lim.	0.	0.	0.	0.	Belw. Lim.	0.	0.	0.	0.	0.	0.

- The 1-hour averaging interval should be used to derive the 0–2-hour χ/Q values, as is consistent with Regulatory Positions 1.3 and 1.4 in RG 1.145
- Section 3.7 of NUREG/CR-6331 (ARCON), Revision 1, states that the larger of the 1- and 2-hour average relative concentrations should be used for the 0–2-hour period.
- For most ground-level release scenarios, the 1-hour averaging interval is expected to be bounding.

Example Process for Calculating 99.5th-Percentile χ/Q

	A	B	C
1	XOQ	1	% of Time Exceeded
2	Abv. Lim.	0	
3	9.12E-03	0	0
4	8.32E-03	0	0
5	7.59E-03	0	0
6	6.92E-03	0	0
7	6.31E-03	0	0
8	5.75E-03	0	0
9	5.25E-03	0	0
10	4.79E-03	0	0
11	4.37E-03	0	0
12	3.98E-03	0	0
13	3.63E-03	0	0
14	3.31E-03	0	0
15	3.02E-03	0	0
16	2.75E-03	0	0
17	2.51E-03	0	0
18	2.29E-03	8	0.091429
19	2.09E-03	39	0.445714
20	1.91E-03	109	1.245714
21	1.74E-03	186	2.125714
22	1.59E-03	290	3.314286
23	1.45E-03	421	4.811429
24	1.32E-03	594	6.788571
25	1.20E-03	767	8.765714
26	1.10E-03	962	10.99429

- The frequency file is intended to be imported into a spreadsheet and divided into columns.
- Once the columns are delimited, the χ/Q exceedance frequencies can be identified.
- A new column can be created that provides the percentage of the time that a given χ/Q value is exceeded.

Example Process for Calculating 99.5th-Percentile χ/Q

	A	B	C
1	XOQ	1	% of Time Exceeded
2	Abv. Lim.	0	
3	9.12E-03	0	0
4	8.32E-03	0	0
5	7.59E-03	0	0
6	6.92E-03	0	0
7	6.31E-03	0	0
8	5.75E-03	0	0
9	5.25E-03	0	0
10	4.79E-03	0	0
11	4.37E-03	0	0
12	3.98E-03	0	0
13	3.63E-03	0	0
14	3.31E-03	0	0
15	3.02E-03	0	0
16	2.75E-03	0	0
17	2.51E-03	0	0
18	2.29E-03	8	0.091429
19	2.09E-03	39	0.445714
20	1.91E-03	109	1.245714
21	1.74E-03	186	2.125714
22	1.59E-03	290	3.314286
23	1.45E-03	421	4.811429
24	1.32E-03	594	6.788571
25	1.20E-03	767	8.765714
26	1.10E-03	962	10.99429

- This can be done by identifying the total number of hours in the .LOG file for each averaging interval (8,750 for the 1-hour averaging interval)
- For this example, this value is H_{Total} in Equation A-1.

$$\%_{Exceedance} = \left(\frac{H_{total} - H_{avg\_int}}{H_{total}}\right) * 100 \qquad \text{Equation A-1}$$

- The user would then subtract the number of hours in the averaging interval column (B) for each χ/Q threshold (this would be 8 for the χ/Q threshold of 2.29×10^{-3} seconds per cubic meter (s/m^3), 39 for the χ/Q threshold of 2.09×10^{3} s/m^3) from the total number of hours, divide by the total number of hours, and multiply by 100 to calculate the percentage of the time each χ/Q is exceeded in the .CFD file.

Example Process for Calculating 99.5th-Percentile χ/Q

	A	B	C
1	XOQ	1	% of Time Exceeded
2	Abv. Lim.	0	
3	9.12E-03	0	0
4	8.32E-03	0	0
5	7.59E-03	0	0
6	6.92E-03	0	0
7	6.31E-03	0	0
8	5.75E-03	0	0
9	5.25E-03	0	0
10	4.79E-03	0	0
11	4.37E-03	0	0
12	3.98E-03	0	0
13	3.63E-03	0	0
14	3.31E-03	0	0
15	3.02E-03	0	0
16	2.75E-03	0	0
17	2.51E-03	0	0
18	2.29E-03	8	0.091429
19	2.09E-03	39	0.445714
20	1.91E-03	109	1.245714
21	1.74E-03	186	2.125714
22	1.59E-03	290	3.314286
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24	1.32E-03	594	6.788571
25	1.20E-03	767	8.765714
26	1.10E-03	962	10.99429

- As the χ/Q values in the first column get smaller, the χ/Q value becomes more likely to be exceeded in the defined wind direction window.
- Therefore, the number of hours above any given threshold increases as the χ/Q decreases.
- For χ/Qs associated with an averaging interval value of 0, this indicates that this χ/Q limit is never exceeded, and therefore 100 percent of the hourly χ/Qs are below this threshold.

Example Process for Calculating 99.5th-Percentile χ/Q

	A	B	C
1	XOQ	1	% of Time Exceeded
2	Abv. Lim.	0	
3	9.12E-03	0	0
4	8.32E-03	0	0
5	7.59E-03	0	0
6	6.92E-03	0	0
7	6.31E-03	0	0
8	5.75E-03	0	0
9	5.25E-03	0	0
10	4.79E-03	0	0
11	4.37E-03	0	0
12	3.98E-03	0	0
13	3.63E-03	0	0
14	3.31E-03	0	0
15	3.02E-03	0	0
16	2.75E-03	0	0
17	2.51E-03	0	0
18	2.29E-03	8	0.091429
19	2.09E-03	39	0.445714
20	1.91E-03	109	1.245714
21	1.74E-03	186	2.125714
22	1.59E-03	290	3.314286
23	1.45E-03	421	4.811429
24	1.32E-03	594	6.788571
25	1.20E-03	767	8.765714
26	1.10E-03	962	10.99429

$$\%_{Exceedance} = \left(\frac{H_{total} - H_{avg\_int}}{H_{total}}\right) * 100 \qquad \text{Equation A-1}$$

- Equation A-1 should be applied to each line in the .CFD file until the exceedance frequency of each χ/Q in the first column is identified.
- The 99.5th-percentile χ/Q value will most likely be between two χ/Q threshold values.
- In this figure, the 99.5th-percentile χ/Q value is bounded by the 2.09×10^{-3} s/m^3 χ/Q (99.55th percentile) and the 1.91E$\times 10^{-3}$ s/m^3 χ/Q (98.75th percentile).

Example Process for Calculating 99.5th-Percentile χ/Q

Using the two bounding χ/Q threshold values from Equation A-1 [2.09×10^{-3} s/m^3 χ/Q (99.55th percentile) and the 1.91×10^{-3} s/m^3 χ/Q (98.75th percentile)], a simple linear interpolation can be used to determine the 99.5th-percentile χ/Q using the following equation:

$$y = y_1 + \left[\left(\frac{x - x_1}{x_2 - x_1}\right) \cdot (y_2 - y_1)\right] \qquad \text{Equation A-2}$$

where,

y	=	the resulting 99.5th-percentile χ/Q value
y_1	=	the lesser of the two bounding χ/Q values
y_2	=	the greater of the two bounding χ/Q values
x	=	99.5
x_1	=	the lesser of the two exceedance frequencies
x_2	=	the greater of the two exceedance frequencies

Example Process for Calculating 99.5th-Percentile χ/Q

$$y = y_1 + \left[\left(\frac{x-x_1}{x_2-x_1}\right) \cdot (y_2 - y_1)\right] \qquad \text{Equation A-2}$$

Based on the χ/Qs in this example, Equation A-2 can be solved as:

$$y = 1.905\ x\ 10^{-03} + \left[\left(\frac{99.5 - 98.75}{99.55 - 98.75}\right) \cdot (2.089\ x\ 10^{-03} - 1.905\ x\ 10^{-03})\right]$$

Therefore,

$$y = 99.5\text{th-percentile } \chi/Q = 2.077 \times 10^{-03}\ s/m^3$$

Benefits of Draft RG 1.249

- NRC regulatory guides provide approaches that the staff considers acceptable for meeting the regulatory requirements addressed by the specific guide.
- At the same time, an applicant has the flexibility to propose alternate approaches to the guidance so long as it also identifies any differences and demonstrates that the applicable regulatory requirements are still met.
- NRC staff has received topical reports and licensing applications proposing the use of an alternate approach to calculating offsite atmospheric dispersion values at the EAB and the LPZ by using the ARCON computer code.

Benefits of Draft RG 1.249

Without applicable guidance, the NRC would continue to require a justification for the applicability of the alternate approach in each application and continue to review them on a case-by-case basis. This could lead to the following:

- Additional staff time to conduct non-standardized reviews
- An increased number of clarifying questions and RAIs during the staff's review
- Increased levels of interaction between the staff and applicant during both the pre-application and application review periods
- More expensive and lengthy application reviews at an additional cost to the applicant

Benefits of Draft RG 1.249

- Draft RG 1.249 describes an approach that is acceptable to the NRC staff to meet the NRC requirements for determining χ/Q values in support of modeling onsite releases to offsite boundaries using the ARCON code.
- Draft RG 1.249 would enhance the efficiency and effectiveness of the review process of licensing applications and topical reports by having a common guidance document as the technical basis for the use of the ARCON methodology.

Questions?