Slide 1:
Hello and welcome to the fire prevention training for labs for the University of Ottawa. I just like to say that this training was created specifically because of the unique nature of fire prevention within a lab as compared to a standard space that doesn’t fit within the same arena as a standard fire safety training. And again, this came about mainly because it is not an uncommon occurrence to have fires of various sizes and difficulties when it comes to working in a research lab. So, knowing when to predict when a fire might occur and being able to rapidly determine whether a fire is capable of being fought and the different techniques and procedures to follow during a fire greatly increases your chances of being able to contain that fire in a safe manner.

Slide 2:
So, as you can see, the course overview goes over quite a bit and it's training should take roughly about half-hour. So, buckle in and hopefully you learn something valuable than this training.

Slide 3:
So, this slide mainly focuses on a basic concept or a very easy way to identify how extinguishers work by identifying the fire tetrahedron. So, you can see there's an image here that shows the three items or elements required for a fire to persist, which is oxygen, fuel, and heat (which causes a chain reaction resulting in fire). So, if you remove any one of these items from the fire, it will extinguish. So that's typically how a fire extinguisher will work. It will try to remove one of these items from the fire tetrahedron (oxygen, fuel, or heat).

Slide 4:
There are various classifications of fire when it comes to its fuel source. So, whether it's a solid that is caught on fire, like simple organics (kimwipes, paper, etc.) or whether it's a chemical fire from flammable source or pyrophorics, peroxides. Some items that can re-ignite more easily when it's being smothered with water or can behave like its own fuel source (or oxygen source), in which case you want to remove the heat. So, we're going to go through the various classifications of fire. So, it will better help you distinguish which fire extinguisher for, or which method is going to be best towards putting out that type of fire.

Slide 5:
So, as you can see here, there are various classifications of fire. This goes through everything that you would normally see when it came to general fire extinguishers. So, you have a types A, B, C, D, E, and K. This goes through things that you'd see in a general (such as) a woodworking shop or in an office. So that's not going to be as effective for us. So, there is a simplified chart which I'll show you now.

Slide 6:
So, as you can see, this has greatly simplifying. So, you have class A, B, C, and D type fires. These are the ones that you would generally encounter within a lab space. I've also distinguished what items that you would more commonly see in a lab space would relate to these types of fire. So, type A fires are generally solids. So, when you have Kim wipes that might be on fire or paper towels, we also have mixed type of fires, which we'll get into in a little bit such as Kim wipes that have been soaked with flammables
or Kim wipes that have reactive metals imbedded in them. So mixed type fires we will go into a fire extinguisher that would be most effective in those situations. You have type B, which would be more like flammable organics. So, ethanol or isopropanol, for example, you have pyrophoric reagents (such as) alkyl lithium’s, and various alkyl aluminums. So that would be class B type extinguishers that would be effective for these. Type C would be electrical fires.

So, most extinguishers that are in your lab space, typically by most entrances to labs would be both a type AB and a type A, B, C extinguishers. Type D extinguishers are specifically for combustible metals or powders. So, things like sodium, lithium, lithium aluminum hydride. These are quite specialty extinguishers and they are very expensive, so they tend to be fewer of them available in the lab spaces specifically. Instead, you'll generally find them in the hallway of the building you're working in. For example, in D'Iorio, they tend to be directly in front of the elevator. It's important to know where these are, especially if you're doing work with these types of reagents.

Slide 7:

So, fire extinguishers will have a picture labeled telling you which type of fire extinguisher is it is designed to fight? I have as more simplifying method by which we bought, by which you can identify them so that you don't have to run up and look for image or symbol on this side of the extinguisher, which we'll go through in a moment.

Slide 8:

So, the various types of fire extinguishers, you have: Water class A. If those are obviously not in labs for an obvious reason. You have carbon dioxide, CO2, extinguisher. Those are Class B and C. And then dry chemical which tend to be class ABC. These are the most common that you’d find in labs. Then you also, as mentioned before, had the dry powder extinguisher. Those are Class D. And those tend to be the tall yellow extinguishers that you typically find in hallways. Any other extinguisher won't be visible in our labs. So, it's mentioned here water as a class an extinguisher and wet chemical being class k. These we won't be touching on as they are not relevant to our spaces.

Slide 9:

So first we're going to look at the carbon dioxide extinguisher for class B and C fires. The main thing I wanted to draw your attention to be the TI discharged time for these extinguishers, which is only eight to 30 seconds. And that's just to alert you to the fact that extinguishers are not designed to fight fires that are out of control or tend to be moving from one source to another. They're more to fight a point source of fire and one that is small to medium in size. So, if it's in the fume hood or if it's on a lab coat, the CO2 extinguisher is it's only going to last long enough to be able to fight that fire. So, if a fire extinguisher tends to be consumed within those 30 seconds and you need to get a second extinguisher. Chances are it means the fire is not worth fighting and you should evacuate the lab. The other thing I wanted to draw your attention to is that the CO2 extinguisher has no pressure gauge whatsoever. And that's always going to be the case. So, this is the easiest distinguishing feature of the extinguishers that are going to be in your lab spaces. So, this makes it an easy way for you to determine which one to grab in those situations? The main thing I wanted to get across with this is CO2 extinguishers are very, very effective obviously, but they're also one of the better choices if you are. I don't want to sound morbid, but if you need to put out a fire that is on a co-worker or a lab made simply because it's the dry powder
as obviously, is a very strong flow and it can cause injury, and it can cause injury where carbon dioxide, the only risk obviously is cold burns. But it isn't based more, more viable to use in the case of when a fire has, has, has gone on to a person's lab coat.

Slide 10:
So, the multipurpose dry chemical, this is the thing that you will use for most fires since it since it covers most classes of chemicals. So, these are the dry powders there. They also have a very short discharge time of only eight to 25 seconds. These ones do have pressure gauges that allow you to visually check the capacity, and this is done once a month by facility staff and they should be signed off for them doing it. So again, if you ever need to quickly differentiate between the type of BC and the type ABC extinguishers. It would be the gauge for the dry chemical ABC extinguishers and then no gauge for the CO2 BC extinguishers.

Slide 11:
Finally, the dry powder extinguisher. These are only relevant for people doing work extensively with metal powders or flammable metals on a regular basis. And as such, they tend to be isolated to mainly bioscience and D'Iorio and you'll find those within most of the hallways in those buildings. It is a good idea to identify exactly where they are, especially if you're doing work with these types of materials. So, these tend to use various, various reagents like sodium Chloride, Copper, or graphite and this is designed to remove the heat and smother the fire at the same time. Additionally, they also have these large nozzles on them which decrease the velocity of the powder being released from. As most flammable metals. They, if they've become aerosolized by, by a significant flow from one of the other extinguishers is more likely to spread the fire as opposed to extinguish it. So that's always good to know as well.

Slide 12:
So, you should all have access to the, to the slides which have been made available. So, I'm not going to go through this in any significant way. This is just showing you the fire extinguisher anatomy. And this can be gone through at your own leisure so that you can help identify some of these items.

Slide 13:
So finally, when it comes to extinguishers, we're going to, we're going to discuss exactly how to use them. And that's using the PASS method. And it should be obvious for the most part, anybody that has seen an extinguisher kind of knows the general procedure. You would take it off the wall, pull the pin, aim the nozzle itself at the base of the fire, squeeze the handle and sweep side-to-side at the base of the fire or at the fuel source for the fire. So, whatever that fuel source might be, whether it's a bottle of reagents or if it's a fire that's fallen onto a floor or whatever the case may be.

Slide 14:
So, in detail how to use the extinguisher. The first step again is pulling the pen. The pin is designed to prevent you from squeezing the handle and accidentally discharging it. As someone who's used a fire extinguisher on multiple occasions, I always find it's good to pull the pin and give a brief squeeze to alert yourself to the how the flow will feel. It also tends to get you out of the fear factor of having to fight a fire. There's always a hesitation to squeeze a handle out of out of concern about how it's going to
behave or that you're not going to be doing it properly. So, kind of a quick pull of the pen and a brief squeeze at the handle will kill, remove the fear. And we'll get you used to how it's going to feel and operate when you are fighting the fire itself.

Slide 15:

So, you're going to take the nozzle and you're going to aim it at the base of the fire. This is to hit the fuel as if you're trying to hit the flames. Obviously, the extinguishing agent will just go through the fire and won't extinguish the flames themselves. So, you're going to squeeze the top handle. As you can see, it says squeeze not pull. So, you want to squeeze it lightly, you don't want to have to pull it which will affect your aim and how it operates. So, squeezing the handle generally is more than enough to release the extinguishing agent.

Slide 16:

Now, tools when controlling a fire. So, this is quite important when it comes to research lab specifically in that there are many, many tools at your disposal. In a typical research lab when fighting a fire that doesn't always include the extinguisher. This also goes through some of the engineering controls that are in it been most of you, most of the space, especially those handles, significant quantities of flammable. But it also gives you again, a bigger tool set about what you could use that are more readily available and easier to control than the extinguishers themselves. So, most fires that most of you will see in your careers in science will be fires that occur within a fume hood. So, the fume hoods are the absolute perfect location for a fire to occur. It has a good flow that's going to be pulling the vapors up and away from the user. The sash protects you again from any fugitive flames and any fumes that are produced by the fire. Noxious fumes again are being pulled away from you. So, the fume hood is absolutely the best location for it. And it also gives you more than enough time to plan your next steps. I can't stress that enough. The main things that have caused the most recent fires and memory within our faculty has been a student overreacting or panicking due to fire. So, if you ever have a fire that is in your fume hood, just know that if you shut the sash for small fires, it might just run out of fuel. So sometimes just standing back and letting a burnout is a perfectly viable option. And alternatively, with you shut the sash and you step back, your chances are having 20 to 30 seconds to plan your next step out to determine which extinguisher might be necessary to alert the other users in the lab that there is a, there is a potential issue and to potentially evacuate the lab if it's necessary. So, it just wants to reiterate that for small fire, especially those located in a fume hood, take a breath, and plan your next steps out your fume hood is perfectly designed to control small fires, at least for a reasonable amount of time. So small fires when it comes to things you could do to try and fight that fire. So, sand obviously and Celite, something that's less known about as, as an effective media for putting out fires. Celite is more effective simply because it is finer than sand. Sand tends to have these pockets that allow the fire to reach air. Sand you'll often use and unless you use a significant quantity of it, the fire will often reignite. So, see light specifically for pyrophosphate compounds is incredibly useful simply because it is more capable of smothering the fuel source for the fire. Again, something that's less thought about. Large crystallization Dish dishes. So simply placing the crystallization dish over a fire that has started in one of your reaction flasks, for example, will burn out any oxygen remaining in the flask and remove the oxygen from that fire again, you're removing one of the items from the fire tetrahedron and the fire will put itself out. So small fires can vary. It can be very easily smothered using these items. And that should be your first go to or thought process if you have a small fire that starts. So, for large fires, this is when extinguisher start
becoming your main option for extinguishing that fire and the large fires. So, this is a, this is a fire that's taking up the entirety of your fume hood or one that seems to be spreading from one source to another. You should grab an extinguisher while alerting the lab users. And the lab users should be alerted to obviously immediately. By the way, guys, I have a fire in my lab where I have a fire in my fume hood. So, they could either assist you evacuate the lab or call 5411, which should also be done for any large fires inside your labs. And then of course, using the past method as previously discussed, you would use that method to put out the fire if it's if it's possible to do so or safety and safe to do so.

Slide 17:

So, this this flowchart kind of goes through the desk that that basic plan of action or what you should be doing through each step of an experiment that might lead to a fire. So, the first half of the most important step in that we will be going through this in a few slides is preplanning your experiment. What tools are there to protect yourself? It is not, is never easy to think in an emergency and to be able to act rationally or quickly when faced with something that is scary. So, if you were able to say, I know for a fact that I'm using these reagents for this experiment, I know that two of them are very flammable and there is a possibility if the seal breaks or if I drop it or go over a certain temperature that a fireable start. What type of emergency equipment should I be thinking about for this experiment? I know it's a flammable liquid. So, it's probably a type BC extinguisher but will be adequate or I have seen light next to me. Whatever the case may be, pre-planning is the best method to protect yourself when it, when it comes to protecting yourself from fires in your lab. So, you've done everything you can. And a fire happens anyways, which does happen. And it starts off as a small fire. Obviously, you have now Sanders see light at your disposal to use see light especially effective for pyro forex and any other method for smothering. Alert other users to the hazard and ask for assistance or tell them just to get out of your way so they don't. You never want to have too many cooks in the kitchen when you have a fire. Simply because obviously the fewer people that are around the fire, the better. So, for large fires or fires that are in multiple sources, you're obviously have the access to the appropriate extinguisher. And because you've preplanned before the experiment, you should know exactly which extinguisher is best suited for fighting that fire. And again, for any large fire, you're going to want another lab member calling 5411 at the same time of the fire so that they are alerted to the possible threat. Now, for a spreading fire. So, this is a fire that it's either gone from your fumehood to the floor or it's going to multiple sources or it's clearly uncontainable, you would immediately evacuate the lab, bringing all the other lab members with you and pulling the fire alarm. And so, without question, as soon as you see a fire moving and it's just obvious that you're not going to be able to fight it immediately, leave the lab, obviously.

Slide 18:

So that goes through the basics of fighting fires, extinguishing fires and how to do it. More importantly, when it comes to science, it's when to prepare for fire. Simply because in science, it is just something that most chemists, biochemists, even physicists, will see on occasion. If you ask any of your professors, guaranteed, they'll say that they'd be seen at least one fire, maybe even one major fire in their spaces. You might even ask them about their experiences. So, in science, it is often possible to predict when a fire as possible outcome. And this is obviously done with risk assessments when the possibility of fire is most common. So obviously, you're working with reagents that are dangerous. Are they high temperature flammable? For example, you needed to heat isopropyl to 80 degrees Celsius. What
controls are in place? Same thing for things like pyrophorics or highly reactive metals and powerful oxidizers often can start fires very easily.

**Slide 19:**

So, risk assessment, this is something that hopefully is something that you've learned along the way or something that's encouraged by your PI's. Risk assessments is the, most important things you could do to protect yourself from fires, from toxics, corrosives, any experiment that you do, you should always be doing a preliminary risk assessment. This only takes five minutes of time to do often, and it allows you to prepare for the worst.

**Slide 20:**

So, to do a risk assessment, the general procedure is to ask yourself what could go wrong. So, you're looking at what is the catastrophic failure that would lead to a that would lead to an issue because its obviously things must go wrong for an accident to happen. So, what is the worst-case scenario in these situations? So, if you're working with pyrophoric compounds, obviously you can have glassware failure or your syringe that you're using to pull up the pyrophoric chemical loses its needle or sprays accidentally or there's a pressure differential, whatever the case may be. What controls and what procedures are in place to protect me in those events? Even things that are simple as uncontrolled heating of solvent or even mineral bath. We've had one mineral bath catch fire since the flashpoint of mineral oil is 135 degrees Celsius. This proves why it is important to inform yourself of the risks involved for any of the experiments that you may be doing, especially if it's one you've never done before. So, reading SDS is a valuable source for this. Again, does not take very long to look these up that readily available online and they inform you of things like chemical incompatibilities that you might not be aware of. So, the next question is, what safety features do I need and what safety features do I have? So, does this reaction or process needs to happen inside of a fumehood or inside of a glovebox? Does the sash need to be down? The answer to that question is always yes. Is the reaction being done under inert atmosphere? Does it need to be a dry solvent, or does it not matter? Do I have an appropriate procedure that I need to be aware of for using a Schlenk line or a specific piece of equipment? What's the PPE requirements? These are they types of questions that you should ask yourself before the experiment takes place. Don't just assume that wearing your lab coat, goggles and gloves is enough. It's always important to find out if there is a specific procedure in place. When in doubt, ask me. Alex, Daniels or health and safety if you're not sure what to do.

So, then what happens if things do go wrong? Do I know how I'm going to react it when something happens? For example, are lab mates aware of the higher risk experiments so they can assist or avoid. When I worked in my lab, whenever I needed to move from my glove box to my fume hoods, especially when there was waste that could have been contaminated with pyrophoric chemicals. I worked with potassium graphite quite extensively. I always made sure; people knew that I was going to do that very quick process. I would say, “By the way everybody, I'm moving from here to here, there might be a fire if one of my Kim wipes catches is contaminated. I have liquid nitrogen sitting on the floor that I can pour on top of this, and the extinguisher is right here. Just be aware that I don't want you crossing my path when I'm doing this.” That was all that was necessary to say. Most people didn't care, and if they did, they were thankful that they were aware that they might suddenly see a spontaneous fire. Sometimes it's even good to allow people know of an appropriate procedure for if an accident happens. Again, this
might sound extreme, but it takes literally two minutes to say this to a lab mate and it could save their life.

Slide 21:

So, the risk assessment in general for specific items. You should always do a risk assessment when working with acutely dangerous items such as pyrophoric compounds or highly toxic compounds. The general procedure should always be letting other lab members know what the type of work you're doing and what the emergency procedure that you've developed is. So, perhaps you would explain what type of extinguisher to use and what to do in an accidental release or exposure. So, for example, you are working with cyanides, you might say to your lab mates, “by the way, if you smell almonds, I am actually working with cyanide so that means that you're potentially being exposed if you smell that, so we're all leaving the room.” A quick and simple conversation that you could all joke about later, but it is legitimately important information for your lab mates to be aware of if you're working with dangerous items.

Finally, and this is only for extreme cases since we don't like people working overnight, especially by themselves, but if for whatever reason you need to leave a reaction running overnight. Post the experimental conditions. What temperature range and what are the contents of the reaction so that people know to avoid it if it's dangerous. They also can determine if your experiment is not at the correct temperature or pressure and can help you adjust. These are simple steps with amazing results when it comes to protecting yourself.

Slide 22:

So, risk assessment for elevated temperature flammables. Many solvents and chemicals used in labs are class 1A or B flammables. This means they have a flashpoint of 23 degrees Celsius or lower, and they're volatile. So, they are very likely to ignite at elevated temperatures. Therefore, if they are accidentally released or your glassware fails, you're almost certainly going to have a flash fire.

When doing elevated temperature experiments, you should almost always be doing them in a fumehood. As this lowers the concentration of flammable vapors in the air. If the concentration of flammables has gone below a certain threshold, there will not be the possibility of a fire. So, a fume hood does help protect you from the possibility of fire. Next, you want to reduce the fuel sources within your fume hoods. You can do this by closing the cap or removing entirely your waste containers and excess clutter while you're doing the experiment. The same should be done for ignition sources. You want to remove Bunsen burners or arching electronics that are not needed inside the fume hood while you’re doing these reactions. And this is just an added point again, simply because there has been a fire caused by a mineral oil bath in our faculty within the last three years. Always be aware of the flashpoint of the oil bath. A mineral oil has a flashpoint of 135 degrees Celsius where silicone oil is almost 300. So significantly higher for, for high-temperature work.

You always want to separate yourself from the hazard. This is something we don't see enough of unfortunately, which is to close the fumehood sash while the experiment is running. We will walk into labs during inspections and every single fume hood sash is completely open. A lot of people believe it's because it increases airflow, which in some cases it does, in that the flow rate has increased but the local flow at your face height is significantly depleted. You might be doing it because you think that's
going to stop a fume hood alarm going off, or whatever the case may be but energy savings and safety, dictates that you only open the fume hood sash when you need to make adjustments to your experiment or to set your experiment up. While it's running, it should be fully closed.

Next, remind yourself of location of emergency equipment. Where the nearest showers are and nearest extinguisher are located, or whether you need items like Celite or a large crystallization dish. Whatever items you feel would be best to have around in an emergency.

Flammable organics can be extinguished using a CO2 extinguisher and powder extinguisher. So, type BC and type ABC extinguishers. Both extinguishes that are in your labs would be more than adequate for fighting flammable liquid fires.

**Slide 23:**

So, these lines are quite important for numerous reasons. Pyrophorics are obviously are a hot button topic simply because there has been a public and well-documented case of somebody dying because of using pyrophoric reagents without knowing the appropriate procedure. So not only is this training important for the case of preventing fires, but hopefully it also informs you of not just the risks, but also that there are very specific procedures that you should be following if you ever need to work with pyrophoric compounds.

So obviously the biggest one and the easiest, way to protect yourself is to never work with pyrophoric compounds until your supervisor or a senior lab member like a postdoc or a fourth- or fifth-year PhD member WITH EXPERIENCE. This is very important, because a person being in the lab for five years doesn't mean that they've ever worked with pyrophoric compounds. Somebody who is aware of the process, obviously the preference is for your supervisor, has shown you how to handle and specifically dispense pyrophoric compounds.

Never work with pyrophoric compounds if you are uncomfortable. It is dangerous enough working with pyrophoric compounds without doing so while your hands are shaking. So, if you are uncomfortable, it is your duty to tell your supervisor that you do not feel comfortable doing this yet and that you just need more practice. Just like everything in life, practice is what makes you improve. So, when you're working with pyrophoric reagents, both your supervisor and health and safety are here to help.

If you feel uncomfortable going to your supervisor then please come to health and safety and we can find you the expertise you need to be able to develop a procedure that's safe and you are comfortable doing.

So, for pyrophoric compounds, you will eventually be able to consult the Health and Safety website, which will have a best practices document for this process but at this point you should consult your lab standard operating procedures for safe handling instructions. If your lab does not have one, simply request one from your supervisor and then again, request training until they've cleared you for working with pyrophoric compounds. When working with pyrophorics, be sure to have a lab member supervised during critical experimental manipulations. This doesn't mean there has to be a person watching, this is just to let people be aware of that you are going to be working with something that will spontaneously catch fire if a mistake is made. So, the critical parts of experiments where it is most likely to cause a fire is obviously through dispensing and quenching pyrophoric compounds. During both processes, other
lab members should be aware that you're doing them at very least. But even better would be to have somebody present and ready to assist should there be a hazard or a fire that starts.

**Slide 24:**

So as mentioned, there is a very specific procedure that exists, and it has been developed for dispensing pyrophoric compounds. I am only going through the very short form version of this process. This is mainly to ensure that you are aware that there are very specific rules when it comes to dispensing these very dangerous types of compounds.

So, the best-practices quick guide. “Sure seal” bottles of pyrophoric compounds should always be secured using clamps when dispensing. This is to prevent them from tilting or falling over during the process. Since it does require quite a few manipulations to occur at the same time. It means that you have hands-free and not holding a bottle of very dangerous chemicals while you’re trying to do this process. You only ever want to use syringes for volumes less than 10 milliliters. Syringes are obviously the easiest way to dispense pyrophoric compounds. And it's the most, since it's the simplest, it's the most used. Anything over 10 milliliters requires syringes too large to be able to be handled safely. This syringe should be twice the size of the liquid dispensed. If you’re trying to dispense ten milliliters, you should be using 25 milliliters syringe, for example. Never pull the plunger directly towards yourself. This is one of the many causes of an accident that happened in the States where the lab member passed away, unfortunately. Not only was she using a syringe that was significantly larger than she should have been doing with much larger volumes and she should have been dealing with, but she was pulling the plunger directly towards herself. The plunger came out of the bottle and then sprayed her clothing with the reagent, in this case, tert-butyl lithium. Next point: inert gas should always be used to relieve the back pressure within the reagent bottle itself. As you’re pulling your reagent out of the bottle, you’re creating a partial vacuum inside the bottle, which is going to cause resistance on the plunger, which will make it more difficult to pull out. This will cause you to strain more against the plunger, which makes it more likely that you're going to pull the plunger completely out of the bottle, which will lead to a fire. Any quantity larger than 10 milliliters should be dispensed using a cannula technique. I’m not going to go through this because the process is quite involved. Not complicated necessarily, but it does require several steps. Just understand that there is a very well understood and written about method for dispensing greater than 10 milliliters of pyrophoric compounds. This is a method that should be discussed with your supervisor. Always dispense pyrophoric compounds in a fume hood or glovebox. Obviously, glove box is preferable for numerous reasons. But obviously, fumehoods are more common. Never perform work for pyrophoric compounds and to ensure your supervisor has approved you to do so.

**Slide 25:**

So, risk assessments for pyrophoric compounds, how are you going to prepare? So just like the volatile flammables, you’re going to separate yourself from the hazard, you’re going to close your fume hood sash when pyrophoric compound is dispensed. You're going to ensure the reaction is under an inert atmosphere. You’re going to reduce and remove ignition sources of flammables from your work area. So again, it should be common practice to seal your waste bins and any reagents that might be left in your human should obviously be removed. And any mess such as Kim wipes and all the rest of it should be removed. Again, if you have glassware failures which happen more often than people like to admit, you want to ensure if there is a fire that it's just your reagent, not something that easily spreads to other
waste bottles are other sources of ignition. Remind yourself of location at the nearest emergency equipment. If the fire is small and controlled, a fire of pyrophoric compounds can be extinguished using celite. CO2 extinguishers are less effective, especially because of how cold they are they can cause water to condense out of the atmosphere, especially on humid days which could reignite the fire. For pyrophoric compounds the most effective methods are going to be your powder extinguisher. So that would be an extinguisher that has the gauge on it.

Slide 26:

So reactive metal, these are typically metals that react with water and/or air. These also have various chemical incompatibilities. Obviously, some metals can catch fire with certain organics and including things like paper and Kim wipes. Again, this is good to know simply because if you’re wiping up and suddenly your hand catches fire, it’s always good to be prepared for that kind of terrifying event.

Read the SDS! Section 10 specifically discusses chemicals to avoid, and it takes 10 seconds to pull one up on Google. Experiments with reactive metals are only to be performed in a glovebox or a fume hood.

Slide 27:

A fire started with reactive metals is most likely to occur during the reaction itself. This usually happens due to glassware failure or loose joints. Alternatively, an unexpected reaction with water, air, or incompatible material that you weren’t aware was there. For example, if you haven’t dried your solvent appropriately, or having a reaction being done in a solvent that is not appropriate for that metal [IE: sodium hydride in dichloromethane which is a less known chemically incompatible mixture]. These are all very common mistakes made and a lot of the time it just leads to a reaction not working but it can occasionally lead to a dramatic fire. So, the other areas where reactive metals with the other times are where a fire is likely to occur with reactive metals would be the transport of reactive waste from glovebox to fume hood. Again, this happened regularly in my lab and again, it was something we predicted and planned for, so it was never an issue. The other time you are most likely to see a fire when using a reactive metal is during the quench of unreacted metal material. Many labs will have a quenching procedure of what to do with unreacted waste. If your lab does not have a quench procedure, I can always help you develop one. So always make sure lab members know what you’re doing if you’re doing any of the above actions. Let them know what procedure to follow in an accident. For example, what’s the fire extinguisher type that you’re going to use, how they can assist during the accident and what to avoid. Again, this is as simple as just telling them where you’re going to be with that reactive metal and that there is possibility of a fire so that they don’t overreact or under react.

Slide 28:

So again, the rules for most fires are the same. I don’t mind reiterating them because I do want to hammer this home, but obviously you’re going to close a fume hood sash while a reaction’s running when you’re using reactive metals. Ensure the reactions under inert atmosphere and reducing and removing ignition sources from your work area. That last point again, it’s important to realize that messy fume hoods are just disasters waiting to happen obviously, as well as it makes you a poor lab citizen in my, in my humble opinion, if you have a horrible working condition because you don’t want to clean your glassware and you wanted to leave things everywhere. It’s not nice to work next to a person who is refusing to clean their work area and it’s a danger to literally everyone around you. So again,
remind yourself of location for your nearest emergency equipment. And then most importantly, reactive metals should be extinguished using type D extinguishers. So, these are the most effective if it provides both a heat sink and smothers the metal at the same time. Powder extinguishers can be used but they are less effective if the fire is too hot. CO2 extinguisher again, can also be used. There is the possibility that a CO2 extinguisher will put out a reactive metal fire. Concern becomes that you are, disturbing the metal particles enough that they spread to other fuel sources. You essentially just agitate the fire and cause it to spread further. The type D extinguishers are less likely to do this.

**Slide 29:**

The most important steps to follow when you're fighting a fire is the four A's. So, the four A's are: assist, assess, activate, and attempt. So very important to note that attempt is the final step. As you'll see, attempt obviously refers to attempting to fight the fire. The first three steps are more important as it's related to your safety.

**Slide 30:**

So, the first item is assist. As you can see in this image, there's a person moving out and incapacitated member of the lab. So, assist those who are in immediate danger or incapacitated. If there is a fire, again, especially if the fume hoods that the fire is inside of a fumehood, you are okay for a few moments. So, close the sash or move away from the fire. Let everyone around you know that there is a problem. Or if you happen to come upon a fire and there's an injured person on the floor, remove them from the area. Getting everybody out of the lab is the most important thing to do if there's a fire, everything else is secondary. And as mentioned before very briefly, if a fire has spread to a lab coat or close the CO2 extinguisher is the most effective.

**Slide 31:**

Assess. So, determine the most effective method for fighting the fire or whether evacuation is necessary. Pre-planning is the key to success when it comes assessing a fire. Remember that small fume hood fires are contained and often sand or celite can effectively smother the fire. So again, few modifiers close the sash and give yourself a moment to just think about this rationally. If it hasn't, if it's not spreading, if it fires relatively small hamlet with your simple methods afterwards, move to your second and tertiary methods of extinguishing. So large fume hood fires or small controlled fires will require extinguisher to put out. If a fire lab is spreading, evacuate the lab immediately and pull fire alarm.

**Slide 32:**

Activate. A lab member should be activating the buildings emergency services by calling 5411 and or pulling the fire alarm if the fire is not controlled. This is an important note, as mentioned, a small fire does not necessarily require you calling for 5411 or pulling the fire alarm. A call to 5411 is only necessary if there is a fire that is significant. Not only does this document the event which but it also means that facilities will be more likely to come and confirm that nothing was damaged within your lab. Fire alarm is reserved at the fire is not controlled and it's spreading quickly because that'll activate the emergency services and that bring the fire department to ensure the fires put out appropriately.
Finally, after those steps, which are more important than the attempting to fight the fire. Once all the first three items are covered, you can attempt to fight the fire and only if the first two steps have been completed and you could feel confident in yourself to do so. Always have an exit to your back in case you need to escape. Never put yourself in a situation where the fire is potentially going to block your exit. Never attempt to fire if there's heavy smoke conditions. Again, you're fume hood is a good location because you're not breathing in noxious fumes. But if there are noxious fumes being produced, leave the space, evacuated the lab. Next, we will discuss the guidelines for fighting fires. Only use of a fire extinguisher if the fire is contained and not spreading. Only if the extinguisher is readily available and that you know how to use it properly, which hopefully after this training you do. Only fight a fire if you can do so without risking your personal safety. Only fight a fire if there is a clear path for your escape. So only if those conditions are met should you even consider using the extinguisher? All other cases your focus will be to evacuate the lab and pulling the fire alarm.

So, in summary, the most important lessons to prevent and fight a fire in lab. And I can't mention this enough is risk assessments and pre-planning before experiments. Sounds boring, is boring, but it's cost-effective it's not time consuming and it's the easiest way to either prevent a fire from happening or to be ready to fight a fire without having to ask important questions such as, what kind of extinguisher I should use. That shouldn't be the question you are asking yourself when you see a fire, you should already be ready and should have a plan of attack in mind.

Actions to take when the fire is discovered, which are the four A's. Assist people in lab. Assess the extent of the fire and how you want to you want to approach the next steps. Activate emergency services such as 5411, or the fire alarm depending on the extent and severity of the fire. Finally, attempt to fight the fire if it is safe to do so and the fire is controlled. Finally, how to use a fire extinguisher. The PASS method, you're going to pull the pin out of the fire extinguisher, aim the nozzle at the base of the fire and squeeze the handle and then sweep side to side to smother the fuel source of the fire. I hope this has been useful for anyone watching. As always, if there are ever any questions or you wish to have a demonstration of how to use a fire extinguisher or have any questions regarding the development of procedures for using any hazardous materials, specifically pyrophoric reagents, and reactive metals. Always feel free to reach out. I'm more than happy to help.