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CONTROLLING SPACE-AGE FIRE HAZARDS

Briefing by Roy D. Terry, Chief Training Officer,
Astronaut Rescue Team

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CONTROLLING SPACE-AGE FIRE HAZARDS

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My subject for presentation this evening is in reference to Hypergolic and Cryogenic materials, the hazards that are associated with them... and, the recommended methods that may be utilized to control them.

It is impossible for me to convey to you in the next 90 minutes all that you will want to know about these materials - or the many problems they pose to the firefighter who is not familiar with their peculiarities; however, I shall do my best because what does matter is that these materials are being transported over the highways and rail networks of the United States in ever increasing quantities...And the one thing that none of us want to happen in our own particular area--may happen:
A major spill of an exotic propellant.

The rig that I am wearing is not just a symbol of the standard firefighter advancements we at the Space Center have made in the past 5 years, but it reflects the general picture of what I believe will be a typical form of dress within the next decade.

We all know that many unkind remarks have been made about the lack of progress in our profession during the last 50 years, as compared to certain other nations..But one only has to stop and consider the immense size of our country and its population to realize the problem...

As a professional firefighter/rescueman, I can do no less than salute the great job that the national firefighters are doing, particularly when over 90% of them are volunteer units who serve their communities while absorbing the responsibility of putting the bread on the table at home. This presentation then--is directed toward the firefighter who has heard of--but doesn't really understand why it is--that in this particular game...Four aces don't always make a winning hand....

It is also directed toward a captive audience who, I am convinced, will appreciate me more as a speaker if I stop rambling and get to the point. The films that you are about to see do not tell the whole story and I shall attempt to critique each one as it is shown to correct certain discrepancies that have come to my attention.

(1. Leave stage and change to uniform or "civvys".)

(2. Return at end of film and point out hazards or propellant fuels.)

Although the film only dwelt on three specific types of fuel and oxidizer, there are certain things you should know about them from a firefighters point of view. UDMH or Aerozine-50 blend, as it is more commonly known, is a fuel most normally used with N_2O_4 as the oxidizer to generate power in the thruster engines of the Lunar and Command Modules in the vacuum of space.

flame propogation will occur immediately on the surface of contact and the resultant fire is similar in nature to a hydraulic oil fire...

(Slide 1) Let's take the example of this slide. If a tanker were to be involved in a wreck that caused a leak directly onto the rusted surfaces of the colliding vehicle, not only would the vehicles be involved in flame, but the unburned spill would generate toxic gas at a ratio that would be dependant upon weather conditions... If it were raining for example, and the temperature was 38°F, ...The gasoff would be less than the 7,000 cu. ft. to-1 gallon ratio mentioned earlier. The material mixing well with water and held in suspension would be diluted and carried off...

(Cut Slide 1)

Now I am not attempting to be scary...just factual...But from my own personal experience with these materials, I would much rather effect a knockdown involving a passenger airliner with inexperienced firefighters than I would tackle a badly ruptured 5000-gallon propellants transporter with conventionally trained structural smoke eaters...Because as you well know the untrained man will do as you tell him because he has a certain faith in your instruction...To the average structural firefighter, a fire is a fire, and he is going to put it out with or without direction even if he has to eat smoke to do it...

(Slide 3) I did forget to mention that UDMH burns with no visible smoke, which definitely compounds the problem.

But we do have one consolation... If there are no fish markets in the area, and you smell fish... you smell UDMH my friend... fish...thats what it smells like...The hotter the weather, the higher the concentration, the stronger the smell...

Slide off

UDMH ignited-like all the hydrazine family--is best handled with large quantities of water...water fog if you please...1 1/2" variable nozzles set at 30^0 for the attack--and 60^0 for the defensive screen...Use in tandem...get in fast, and get to the heart of the fire from the Upwind or high flank direction. Cut the thermal column to prevent explosions and flood the rupture area to avoid re-ignition of the flowing liquid. Leave the exposure mop-ups to the flankers...Do-not, I repeat Do-not, expose personnel to direct contact with the hydrazine liquid...There isn't too much you can do about the gas-off except alert the downwind areas and conjure up some high winds from somewhere. Always, ...Always flush the personnel who have been directly exposed with lots of water...even if it means stripping to the buff...it may shock a few sensitive people, but then I wouldn't worry about that too much...

(Slide 4) N_2O_4 is a horse or gas or a different color...Reddish-Orange to be exact...it has a characteristic odor of ammonia...its an oxidizer...it will not burn without a fuel...

In its diluted form, it converts to nitric acid and the residuals will form a crystalline salt composition. If spilled on bituminus asphalt it may ignite spontaneously...depending upon whether or not the contractor who built the road put an excess of high base petroleum in the mix. If the tarmac is tacky due to hot sun--you may have a fire by spontaneous reaction... If its cold and brittle, the chances are good that all you have to worry about is gas-off... and chief...you had better worry...maximum acceptable concentration is 1 PPM, by gas volume in air over a 24-hour period. Again 5000 parts will kill...Gas-off ratio is higher...approximately 8500 cubic feet per gallon at 72°F is a dangerous dose. This is due to the heavier specific gravity of water... It weighs 12.4 pounds per gallon as opposed to 6.8 of UDMH. Use the same basic techniques with water...but CO_2, dry powder, ABC, PK, will cause reactions with the liquid material and convert to carriers or catalysts. Don't use them until we can come up with something to turn the trick...

Now, let us speak of respiratory protection: How to take care of the proboscis.

(Slide 5) When we speak of liquid missile propellants or industrial chemicals the days of "Old Leather Lungs" are over...he may have leather lungs when he starts...but if he mixes with this stuff he winds up with tissue paper...and not much of that...

(Slide 6) I wouldn't be too confident about those cannister masks either...Hypergolics don't mix too well, remember? It's happened... I've made it happen...Cannister masks will catch fire under the right conditions...Don't use them in this environment...Apart from the fact that they are only good for 3 percent concentrations. Use a reputable, self-contained breathing apparatus...there are many good units on the market...

Now let me say something about cryogenics. The true translation of the word cryogenic means cold materials...and when we refer to liquid hydrogen, liquid helium, liquid oxygen and nitrogen we are referring to materials with temperatures of minus 290^{0}F to absolute zero...To maintain these materials in a liquid state they must be stored and transported under pressure...

For example... liquid hydrogen is a fuel that is transported in a dewar tank with an envelope of liquid helium...Liquid helium converts to an inert gas in its free state. It is normally stored at $\approx$-453.8^{0}F. Heat exchangers are utilized to maintain pressure on the hydrogen to prevent excessive buildup of gases which could easily cause a rupture of the system.

If a liquid hydrogen tanker were involved in an accident and the helium blanket escaped, venting of the hydrogen gas would occur due to radical temperature change almost immediately...Fire at the vent stack is not unusual under these circumstances...but unless the main tanks are ruptured it is advisable to be cautious when approaching vents or piping...

Hydrogen gas burns with an almost invisible flame and although there is little heat from the side of the flame, temperatures of 1500°F are not uncommon at or about the tip, depending upon the size of the leak.

Liquid oxygen will not burn by itself...but it will vigorously support combustion of any fuel element in the presence of spark or flame... In addition, a spill of liquid oxygen on bituminous asphalt or other materials with a hydrocarbon base such as oil, grease, or petroleum derivatives will form a "Gel" that sometimes developes an explosive force equal, by weight, to nitro-glycerine.

I cannot over-emphasize the necessity for traffic activity to cease immediately...Douse the smoking lamp and establish roadblocks no less than 2000 feet from the site of a ruptured LO_2 transporter if no fire has occurred... If you must make a preliminary reconn; step softly behind a wide pathway of low velocity flooding water...and then only when attempting to save a life! Do not direct high pressure straight streams at any portion of the impact or spill area; because a gel composition is trickier and more unpredictable than a jealous woman...very sensitive to shock... even shockwaves transmitted from a distance.

(Slide 2) Don't, whatever you do, go charging in like The Light Brigade... its safer to stay home and play Russian Roulette.

There is one other small matter that I should like to bring to your attention. Gaseous oxygen, on a hot day is as refreshing as a cold beer and there is no real harm in staying in the gas-off...

As a matter of fact it will do a good job of flushing your lungs...But gaseous oxygen has an aggravating habit of becoming trapped in the lint and threadwork of clothing and oxygen, as you well know is one of the elements that can make a believer of a pyromaniac...To the uninitiated, a romp in a cloud of gaseous oxygen and a well-earned cigarette immediately afterward will make him the subject of hot conversation for many weeks to come...It is a matter of record that 3 technicians were working in a pressurized pure oxygen atmosphere...for no more than 20 minutes...This was in the early days of experimentation...Upon completing their work they retired to the change room where one of them thoughtlessly lit a cigarette.

He immediately burst into a sheet of incandescent flame...his two friends rushed to help...there was very little need for cremation services for all three as you can well understand.

(Slide 7) It would be very unusual to find a charged manifold on a tanker transporting cryogenic materials over the highways...but if you should, there is one thing that simply is not done...and that is to chip ice from frosted pipes or fittings...This character in the picture is setting it up for someones wife at some future date...to become a widow. Chipping on pipes that are subjected to sub-zero temperatures weakens them and although they are periodically subjected to hydrostatic or pneumostatic testing--a fatal leak could develop...

This next film will give you a 10-minute dramatization of the behavior of super-cold materials.

(After Film)

At this time I believe it would be a good idea to take a 15 minute break before the concluding section of this program.

My team at KSC has the prime responsibility of rescuing astronauts and their support teams in case of fire or other disaster on the launch pad. We started the training program from scratch in 1965 and built it up to meet the advanced needs of rescue requirements for the Apollo-Saturn program. The whole concept was so advanced, that we had no guidelines to follow. It was a whole new ball game. You have already seen the special problems of hypergolics and cryogenics materials. Now, compound these hazards with the complexities of the largest launch vehicle of the United States program.

(Slide 9, LC39 Egress Route) As the bird stands on the pad in flight configuration on the mobile launcher, there are three astronauts in the command module over 400 feet above ground. On the Saturn V there are 41 rocket engines, hundreds of pieces of explosive ordnance, and enough fuel to make it a potential bomb equal to one million pounds of TNT. Should a leak or fire develop in the last few minutes of the count - the astronauts and closeout crew have ~~two~~ three ways out.

One way is down the tower elevators and through the slide tube into the blast room under the pad. The other is by the same route to the pad area and entry into the armored vehicles where we, the rescue team, are waiting for them. The other is down the slidewire in a 9-passenger cab. But-suppose the astronauts are injured or otherwise incapable of getting out under their own power? Should this happen, my rescue crew, is stationed 1800 feet from the pad. It is our job to go up and bring them down. The team is not only expert in advanced techniques, but have every move planned and rehearsed through many practice sessions in closely simulated disaster situations. Our men get a realistic feel of hypergolic fire and the subsequent explosions. They take turns rescuing me from a "boilerplate" capsule very close to the pit. Now we've prepared a short film showing some of these exercises, and although the size of the explosions would normally be far greater, I hope you will understand that at the time it was taken... strict safety precautions were invoked... Incidentally, an updated and more exiting film is in process at this time...

(KSC training program film - 19 minutes)

There you have a very few suggestions from our years of working with exotic fuels in the space program. Before signing off, I'd like to quickly touch base again on these pointers, which we've also made up into posters that you can see at your convenience.

(Slide 1) Remember that exotic fuels and chemicals are on the highways, rails and waterways - they are a very real potential hazard in your own back yard, and you should be preparing to meet this hazard.

(Slide 2) Don't rush in where angels fear to tread... make a careful size-up.

(Slide 3) Know your materials - hydrazines are toxic, inflammable and hypergolic with rusty surfaces. They have a characteristic fishy odor. Use self-contained breathing apparatus and total protective clothing.

(Slide 4) Don't get caught red-handed in N204 gas-offs. These also are highly toxic. Use breathing apparatus, stay upwind of the cloud, if possible. Alert local authorities. Don't hose the material down into sewers.

(Slide 5) In this age of chemicals and propellants, old "leather lungs" shown here is dead. Again, use proper breathing apparatus, at all times.

(Slide 1) Know your cryogenics. Hazards consist of extreme cold, danger of expansion when evaporating, complications of a LOX spill on pavement. Keep traffic away, notify authorities.

(Slide 7) Don't permit anyone to play around cryogenic tankers, especially this type who likes to cool off on a hot day by chipping ice from the pipes. He is apt to be permanently cooled off. And he may take you with him!

(Slide 8) Lastly, do not dread these special hazards, but be prepared for them using these simple tips learned through experience.

And now, I'd be happy to try to answer any questions you may have on this subject. If you can return home with some usable ideas out of this presentation, I will have done my job.