# Modern Marvels

## Firefighting Part Two:
## Extreme Conditions

**The History Channel 1997**
**Writer/Producer/Director: Terry FitzPatrick**

## OPENING INTRODUCTION

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| Layered montage of fighting fire in a house | **NARRATOR:** It's one of history's deadliest jobs fighting the flames to save lives and property. |
| oil well fire, smokejumpers in air, airplane firefighting | It's even tougher when fire breaks out under extreme conditions. Fighting fires here requires unconventional tools and techniques. Throwing dynamite into a roaring oil well. Parachuting into a blazing wilderness. Smothering a flaming airplane with foam.<br><br>Next on Modern Marvels: Firefighting in extreme conditions. |
| **modern marvels series open** | |

**ACT ONE**

Footage of oil wells on fire

**NARRATOR:** A oil well fire is like no other spectacle on earth: a blow-torch, fueled by a rocket of oil & gas blasting out of control.

**Shellman:** "A blowing well that has caught fire is a perfect example of mother nature out of control. To see this column of fire three or four hundred feet up in the air, it's a pretty awesome spectacle."

**Bowden:** "It is amazing. It's amazing that mother nature can put that much energy coming from the earth."

**Kinley:** "Almost more impressive than the heat is the sound. You feel as though you're being bombarded, hit. After a while you -- you get sort of numb and you can't get numb while you're working on a fire."

**Matthews:** "To work on a well you certainly can't be afraid of it. But you have to respect it all the time. Cause it will kill you."

moving bomb into place

**NARRATOR:** It requires a special breed to tame a burning wild well. It also takes firefighting's most unconventional tool: dynamite.

blast goes off---fire goes out

It's a risky technique, first developed in an era when the world's oil fields were the devil's playground.

segment title: Hell on Earth

oil drilling footage from 1920's, gusher from derek

**NARRATOR:** Oil well fires are as old as the oil business itself. When an oilman cried "gusher," it wasn't necessarily good news. It often meant his drilling rig was out of control.

**Shellman:** "In those days, there wasn't a whole lot to do to control a well. Those wells were allowed to blow. And if they caught fire they'd sometimes burn for years."

graphic

**NARRATOR:** "Blowouts" occur when drillers underestimate the pressure of oil and gas underground--known as "geo-pressure." Engineers try to compensate for geo-pressure by injecting heavy mud into the hole as they drill. Sometimes, the mud isn't heavy enough to hold back the oil and gas. The result is a "blowout."

footage of early oil fires

Blowouts can twist a drilling derrick into a maze of jagged debris. A spark--or the heat from a motor or light bulb--can set the gusher ablaze, bringing catastrophe.

**Shellman:** "These wells were within a hundred feet of each other and so if one well caught fire, well all the wells downwind caught fire."

early fire footage, Kinley family photo, footage of putting nitro into a well

**NARRATOR:** Early on, crews injected steam into the flames, hoping the vapor would cool the blaze and cause it to stop. in 1913, a family from southern California proposed a radical new approach. Karl Kinley was handy with nitroglycerine. As a professional "shooter," Kinley triggered explosions underground to increase the flow of oil on stubborn wells. Kinley had a theory about fire.

visual metaphor footage of blowing out a candle and an antique oil lamp.

**Actor's voice:** "I conceived the idea of 'shooting out' the flame. The idea is just like that of blowing out a candle or an oil lamp. The force of the breath blows the blaze from the fuel. I figured if I could get a strong enough 'breath,' I could do it. Karl Kinley."

Kinley photo with the bomb

**NARRATOR:** On April 29, 1913, Kinley and an assistant tossed a nitroglycerine bomb--by hand--into the wreckage of a burning well in Taft, California.

**Kinley:** "They placed the shot and it blew the derrick away, and it also blew out the fire."

Myron Kinley photos, as young boy and as a man, footage of Myron at work

**NARRATOR:** Kinley was unhurt, and his shot was heard round the world. A shot witnessed by Kinley's son, Myron, who would perfect this revolutionary technique as he took over the family business. In the 1920's and 30's Myron Kinley surpassed his father to become the world's premiere wild well specialist.

**Kinley** "Myron looked on the fire as an enemy. And he found it very satisfying to know that he could put them out."

Footage of Kinley crew

**NARRATOR:** Kinley moved to Texas and recruited a team of daredevil assistants, men who would eventually become the superstars of the oil well firefighting industry.

**Matthews:** "Well, you know we all had a lot of respect for Mr. Kinley. We called him the grandfather of the oil firefighting business, of which I suppose he was."

Kinley historical footage documenting process of wild well control

**NARRATION:** Kinley pioneered the three-step process of bringing a wild well under control. First, crews must remove the twisted debris that causes the flames to shoot in several directions.

**Matthews:** "To work on the well head itself is hard to do underneath a drilling rig. It's very dangerous because something on top may fall. So the first thing you got to do is prepare to remove the drilling rig off there."

Well control footage continues

**NARRATION:** With bulldozers and booms, crews methodically drag away the drill pipe and other debris. When the debris is gone, it's time for the second step: preparing the explosives.

**Bowden:** "We'll adjust the explosive to the fire, the height of the fire, the diameter of the fire. A lot of the shots are 150 pounds, some are 250. In a 55-gallon drum, you can put 497 sticks of dynamite."

Well control footage continues

**NARRATOR:** The explosive charge, wrapped in heat-resistant asbestos, is backed into place.

blast goes off

**Matthews:** "The concussion from the shot knocks the oxygen away and fire doesn't burn without oxygen. By the time the oxygen gets back, the fire is out and the water is keeping it cool, so it shouldn't start back on fire."

Well control footage continues

**NARRATOR:** With the fire out, crews begin the third part of the process: capping the blown-out well. Working with brass tools--to avoid sparks--the men replace the damaged well head. For this part of the job, firefighters hope for a windy day.

**Shellman:** "If there's no wind blowing, and the gas is laying close to the ground, it's very frightening because the whole thing could just ignite."

closing off a well

**NARRATOR:** It can take weeks to bring a burning blowout under control. Although the process is well-established, no two fires are ever alike. And occasionally, firefighters encounter a problem they've never faced before.

aerials of wells on fire in Kuwait

That was the case in 1991, in Kuwait. The Persian Gulf war created the biggest oil well firefighting challenge in history. Iraqi troops set more than 700 wells ablaze before United Nations forces drove them from Kuwait during Operation Desert Storm. Every wild-well specialist in the world was called upon to battle the fires.

**Matthews:** "We'd never seen anything like that, nobody had. And it was an awesome looking sight. You could be standing out there midday and the smoke was so bad you couldn't see your shoes."

Footage of different well control techniques being used in Kuwait

**NARRATOR:** With so many wells on fire, Kuwait became a proving ground for a wide range of new technologies. Hungarian crews used a vehicle with twin jet engines. They literally blew fires out with thousands of pounds of thrust. Kuwaitis used high-volume water pumps, which delivered more than 12-thousand gallons per minute. The force of the water was enough to also blow fires out. U.S. crews used long metal smokestacks that allowed them to work on damaged well heads without having to put the fire out.

**Bowden:** "If you go over the fire with your capping stack, then we're raising that flame above us approximately 30 to 40 feet, and it's a lot cooler for us to work under it and a lot safer."

Wild well control footage in Kuwait

**NARRATOR:** By allowing the fire to burn until a new well head is in place, crews can minimize damage to the environment. The fire consumes much of the oil, avoiding a toxic pool of pollution. It took 7 months to extinguish the Kuwaiti oil fires. Never before had so many wells been on fire at once. Remarkably, despite the danger, no firefighters were killed.

Dip to black

Footage of forest fire, ground crews, smokejumpers, airplane water bombers

**NARRATOR:** Up next: battling America's forest fires, from the days of picks and shovels, to the modern aerial assault.

Dip to black

**ACT TWO**

Small forest fire footage

**NARRATOR:** Fire has always been part of the American landscape, serving an important ecological role. Occasional fires--sparked by lightning--creep along the forest floor, cleansing the woods of debris.

Images of Old West pioneers

This natural process was disrupted in the 1800's by reckless pioneers. Their actions would prompt a national crusade to protect America's woodlands from destruction.

Segment title: "Dragon Devastation"

Footage of steam trains, re-enactment of clearing woods for homesteads, illustration of Peshtigo residents fleeing

**NARRATOR:** By the late 1800's, fire was a plague on the land. Major forest fires were touched- off by the sparks from steam locomotives and careless burning by farmers when clearing land for crops. In 1871, a forest fire wiped out the farming town of Peshtigo, Wisconsin, claiming more than a thousand lives.

**Pyne:** "These fires did a great deal of damage and provided part of the background for thinking that the country could not continue to burn itself up this way. It was no longer the friendly flame or an extension of the hearth. It had become a kind of holocaust."

Roosevelt footage, portrait of Pinchot

**NARRATOR:** President Theodore Roosevelt took action on March 3rd, 1905 by federalizing large tracts of land and creating the U.S. Forest Service. The agency's first chief--Gifford Pinchot--was told to conquer forest fires at any cost

**Pyne:** "Pinchot called fire the "Dragon Devastation." So he could imagine a kind of crusade of foresters--if you will, as knight-errants--out to slay this dragon which was destroying the countryside and breathing fire as mythical dragons would."

Early forest fire fighting footage, ground crews, airplanes, fire tower spotters

**NARRATOR:** Early efforts were not successful. Armed only with hand tools, firefighters died by the dozen. Technology slowly began to even the odds. In the 1920's the Forest Service began aerial patrols with radio relays to the ground. Foresters knew if they could spot a fire quickly, they'd have a better chance of putting it out. Still, spotting a fire, and getting to it, were separate problems.

**Pyne:** "You want to get to these fires as early as possible. The longer they linger on the landscape, the bigger they become. But in areas without extensive roads and trails, you need some other way to get people in and so you begin dropping them from planes."

smoke jumper footage

**NARRATOR:** In 1939, the Forest Service began an air war on fire. The "Smoke Jumpers" were born.

**Williams:** "You could put people and equipment by parachute in these remote areas, versus walking people in or hauling in mule trains to haul heavy equipment, you could do it all by air."

Smoke jumper training camp footage

**NARRATOR:** Smoke Jumper boot camp prepared recruits for the perils of skydiving. Smoke jumpers were among the first people to ever use parachutes. Each man wore a padded canvas jumpsuit to protect him if he landed in a tree. The protective headgear looked like a cross between a catcher's mask, and football helmet. Smoke jumpers could reach a small, remote fire in a matter of hours. On the scene, their strategy was simple. Scrape a circle around the fire to remove the fuel it needs to advance. This technique is still in use today.

**Williams:** "What we would do is that we'd start at the foot of the fire, and we'd cut fuel breaks--or what we refer to as 'fire lines'--from the back of the fire along the flanks and eventually try to pinch off that very active front or head of the fire."

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| setting backfire footage, graphic | **NARRATOR:** With fire-lines established around a blaze, smoke jumpers fight fire with fire. By setting small controlled "back-fires" near the fire line, they widen the dead zone. When the forest fire arrives, there's nothing left to burn. The fire goes out. |
| Contemporary forest fire fighting footage | Today's firefighters have the benefit of decades of technological advances: to predict fire behavior, to battle the blaze more efficiently, and work with a greater margin of safety. |
| Heavy equipment in action | Bulldozers are now used to rapidly cut fire lines. Helicopters can pump water from nearby lakes and drop it directly on the flames. Cargo planes can drop even heavier loads. The "super-scooper" can make a touch-and-go landing on a lake or in the ocean...and carry 16-hundred gallons of water back to the flames. On some runs, pilots mix water with a special fire-retarding chemical. The reddish mixture also contains fertilizer and seed, to promote rapid plant growth in fire-damaged terrain.<br><br>Today's smoke jumpers have better equipment too. Jump suits are made of Kevlar, the fabric used in bullet-proof vests. Every jumper carries an emergency heat-resistant shelter. |
| Show and tell soundbite opening shelter in airplane hanger | **Williams:** "It's like a pup tent. You spread it, you crawl inside of it, and you anchor it down with your hands in leather gloves. And of course you'd be in firefighting clothing. Spin it around, get inside of it. It's about the size of a person." |
| Demonstration footage of shelter in field | **NARRATOR:** The survival shelter is made of fiberglass and aluminum. Fire fighters inside them can survive temperatures of 500 degrees. Some firefighters call the shelter their "shake-and-bake" shell. |

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| Yellowstone forest fire footage | Despite the impressive array of equipment to fight forest fires, sometimes fire still wins. In 1988, nearly 800-thousand acres of Yellowstone National Park went up in smoke. More than 9-thousand firefighters battled the blaze. Helicopters dropped more than 10-million gallons of water. But nothing worked.<br><br>**Pyne:** "We had an enormous technological armada, and the fires burned as they were going to burn regardless." |
| Yellowstone fire footage | **NARRATOR:** Generations of successful spot-fire fighting had allowed too much debris to build up in Yellowstone Park. When fire broke out in a drought-stricken year, it was unstoppable.<br><br>**Pyne:** "As long as we have public wild lands, we are going to have wild land fire from one source or another. The only issue is what kind of fire we have. If you put out all these little fires that are easy to take care of in burning through the surface, you create conditions in many environments where you can create much larger fires." |
| controlled burn footage | **NARRATOR:** In many places, officials now let fires burn--or set small fires themselves--to mimic nature's fire cycle. While this strategy may work in a remote wilderness, authorities face a dilemma when forest fires threaten homes and businesses. |
| LA brush fires, historical footage of Brentwood fire | As suburbs move farther and farther into wild country, the threat of disaster grows larger. This problem surfaced in the 1960's when a brush fire raced through the fashionable Brentwood and Bel Air sections of Los Angeles. Nearly 500 homes were destroyed. |
| Modern LA suburban forest fire footage | Forest and brush fires have continued to plague Los Angeles and other sprawling metropolitan communities. It's a problem that won't be easy to solve. |

**Pyne:** "The solution is not really a technological one. The solution is one of zoning, planning, or building structures out of non-combustible materials. As long as you build houses or towns out of forest materials, they are going to burn just like forest fires."

Dip to black

footage of London firefighting during WW II

**NARRATOR:** Up next: battlefield firefighting, including the heroes who saved London from total destruction during the Nazi fire-bombing blitz.

Dip to black

**ACT THREE**

Segment title: Fire Under Fire

Vietnam napalm bomb and WW II flame throwers

**NARRATOR:** Fire has been one of history's most potent weapons. Perhaps nowhere was fire more deadly than the battlefields of World War Two. Flame-throwing tanks could burn an enemy to death more than 100 yards away.

London air raids, Nazis marching in Paris

No place witnessed more heroic firefighting during World War Two than London, during the Nazi fire-bombing blitz. After the fall of France in 1940 the British knew trouble was coming.

**Grant:** "The British recognized the need to prepare for possible invasion and possible bombing of their cities, and they did take a number of steps to be prepared. And those steps in the end did pay off."

Recruiting posters, fireboats

**NARRATOR:** Authorities recruited 273-thousand men and women to be firefighters, positioning them strategically throughout the city. London quadrupled its fleet of fire boats, from 5 ships to 20.

bombing and fires

When the bombing began, the German Luftwaffe tried night after night to inflict maximum damage.

Newsreel of London bombing

**Newsreel announcer:** "Down below the London sky watchers were anxiously probing the night. All-out air-bombardment was by now starkly familiar to Londoners. Yet each time it was so dreadfully new. Each new shower of incendiaries so terrifying. Here's how it went, the night of May 10, 1941."

bombing newsreel sequence

**Grant:** "A typical incendiary attack would start somewhere in the vicinity of two thousand fires, and that occurred every single night. So the challenges that faced the firefighters of London and the surrounding communities were incredible."

WW II footage

**NARRATOR:** The London fire brigades faced an entire city ablaze.

**Errington:** "We were going back over London Bridge--and this was nighttime, you see. We stopped for a moment and we looked to the left, and we looked to the right, and it was the most magnificent site that you could see. If it hadn't been so tragic it was wonderful. It looked as if all London had been burned down."

**Grant:** "Not only are you trying to deal with buildings that are on fire and could collapse at any moment, but bombs are dropping around you. Buildings are blowing up. Not only that, there are bombs that haven't exploded that are still live bombs that somebody needs to detonate."

**Errington:** "I have often said to myself, why wasn't I afraid? You don't have any fear at all. You just do."

London firefighting footage, portable water tanks

**NARRATOR:** One of the biggest challenges in fighting the fires was water. Bombs destroyed London's water pipes. The British, however, expected this to happen and built thousands of portable water tanks. Firefighters could construct an emergency water system on the spot.

Churchill touring bomb damage

The London Blitz lasted 8 months. 14-thousand people were killed. British Prime Minister Winston Churchill credited firefighters with saving large portions of London from ruin, calling them "heroes with grimy faces."

**Churchill** "If the British empire and its commonwealth last for a thousand years, men will still say this was their finest hour."

Dip to black

Airplane crashes and burns, firefighters respond

**NARRATOR:** Up Next: terror at the airport. What firefighters do to save lives when airplanes crash and burn.

Dip to black

**ACT FOUR**

jets taxi, take off & land, crash scene

**NARRATOR:** There are 160-thousand takeoffs and landings every day in the United States. Nearly every one is perfect. However, when things go wrong at the airport, there's an added dimension of terror.

Segment title: No Escape

Hindenburg over New York city, comes in to land

**NARRATOR:** Aircraft fires date back to the dawn of commercial aviation. May 6th, 1937. The "Hindenburg."

**Newsreel announcer:** "The ship is riding majestically toward us. It's practically standing still now. They've dropped ropes out of the nose of the ship. Get this Scotty! It's bursting into flames! It's falling on the mooring pad! This is terrible! It's a terrific crash ladies and gentlemen. The smoke and the flames, now! Oh the humanity!"

Hindenburg aftermath

**NARRATION:** In 32 seconds, 35 people were dead. Surprisingly though, 63 passengers and crew members survived the Hindenburg disaster.

modern aircraft fire scene

Even today, as bad as a crash scene looks, more than 80-percent of the passengers involved in aircraft fires survive.

**Barrett:** "People are not necessarily doomed in an airplane crash. If the plane drops out of the sky: yes, there is probably a lot of problems with survivability. If it has an accident on landing, or has an in-flight emergency and then lands with an in-flight emergency, it's very survivable."

Airport crash fire trucks respond

**NARRATOR:** The key to survival is rapid response.

**Barrett:** "Fire can burn through the fuselage between one minute and a minute and a half. So if the fire is directly impinging on the fuselage on impact we've got a very short time to get there."

Airport fire training footage

**NARRATOR:** Airplane fires require different equipment and tactics than house fires, primarily because airliners carry thousands of gallons of fuel. Firefighters use a mix of water and flame-resistant foam to snuff-out the blaze. Foam prevents oxygen from reaching the flames. Airport fire trucks are fully self-sufficient, ready to pump the moment they arrive.

**Wright:** "The rescue vehicles that we have today are race horses. It can do zero to 50 miles per hour in about 21 seconds. It carries over 1000 gallons of extinguishing agent and 500 pounds of dry chemical and it can go anywhere on or off the airfield property. It doesn't have to be on approved cement or blacktop. It can go anywhere."

Demonstration footage

**NARRATOR:** The latest innovation is a 55-foot telescoping boom. One truck can quickly cover an entire aircraft. To take the fire attack inside an airplane, the boom can poke through the fuselage.

**Wright:** "Should there ever be a need to provide interior fire suppression, we could inject water at the rate of 375 gallons a minute through this pipe into the interior of the cabin very early into the event."

hanger doors open, engineer walks along jet fuselage

**Narration:** Engineers at the Federal Aviation Administration --the F-A-A--are working on other ways to make airplane fires less dangerous. This is the FAA research center in Atlantic City, New Jersey. Here, scientists set real airplanes ablaze.

**Sarkos:** "The most reliable way of studying fire and developing improvements is to actually set the real thing on fire in a very realistic fashion."

FAA test fire footage

**NARRATOR:** Full-scale tests document the way flammable gasses build-up inside an airplane cabin. Smoke begins to build from the ceiling downward. Escape is possible for three minutes, until a phenomenon occurs called "flashover."

**Sarkos:** "The heat from the fuel fire, as well as the heat radiated from the smoke layer, raises the temperature of these materials to the point where they spontaneously ignite. The combustion will occur so rapidly that it will actually starve the oxygen in the air, and the conditions throughout the cabin will become virtually non-survivable within a matter of seconds."

FAA fire test footage

**NARRATOR:** These tests have led to regulations requiring flame-resistant airplane seats, which reduce the buildup of combustible gas inside a burning plane. FAA research has also developed equipment to stop fires inside airplane baggage compartments. Most airliners have systems to flood the compartment with Halon gas when smoke-alarms go off. Halon chemically prevents oxygen from reacting with flammable materials--eliminating the fire.

Dip to black

Segment title: Flaming Failure

planes crash in FAA tests

**NARRATOR:** Not all FAA experiments have gone according to plan. In the 1970's and 80's, scientists tried to develop a safer formula for jet fuel. When an airplane crashes, jet fuel forms a highly-flammable mist that erupts into a deadly fireball.

**Fenton:** "This fireball mist will track and follow and attach itself to the wing or the tail of the airplane. And that becomes an inferno entirely around the outside of the fuselage, so people that are in the cabin, have survived the impact, but yet can't get out."

lab experiment tests on new fuel

**NARRATOR:** In the 1970's, chemists developed an additive that stops fuel from forming a mist. On December 1st, 1984, researchers prepared for the ultimate test: the crash of a remote-controlled Boeing 720.

**Fenton:** "We had spent six or seven years preparing for this one experiment, that would demonstrate the properties that we had seen in lower-scale tests."

multiple camera angles of the crash

**NARRATOR:** As the jet came in for a controlled, wheels-up landing on its belly, something went wrong.

**Fenton:** "The engine exploded. All the fuel dumped right on this exploding inferno of an engine, and there was an immediate fireball."

Footage of test dummies inside the burning plane

**NARRATOR:** The crash hadn't gone as planned. However, the fire would have been worse if this plane had used regular jet fuel instead of the experimental formulation. Cameras inside showed most passengers would have survived. Still, the test and the fuel additive program, were regarded as failures.

commuter plane crashes and passengers are safely evacuated as fire crews move in with foam

Despite the fuel program setback, today's airliners are the most fire-worthy planes ever built. Accidents are inevitable. But more and more passengers are surviving airline disasters because of the efforts of aircraft engineers and airport fire departments.

Dip to black

NASA footage

**NARRATOR:** Up next: fire in outer space. It looks different, it burns differently, and it's more dangerous than anything on earth.

**Lovell on radio** "Okay, Houston. We've had a problem here."

dip to black

**ACT FIVE**

Space shuttle liftoff

**NARRATOR:** It's a deadly irony of the space age. The force we use to escape earth's gravity can kill an astronaut in an instant.

Segment title: Fire in the Sky

Footage of Apollo rocket on the pad, crew, charred capsule

**NARRATOR:** January 1967: Apollo One, America's first moon shot. Vigil Grissom, Edward White and Roger Chaffee die on Launch Pad 34. An electrical fire consumes their capsule during a training exercise.

challenger liftoff and explosion

January 1986: the Space Shuttle Challenger. A fuel fire destroys the ship 71 seconds after launch. Seven astronauts are killed.

Apollo 13 liftoff, fiery stage separation in orbit

NASA engineers have always known that liftoff is a risky part of space flight. In the 1970's, they also learned about the hazards of fire in space.

**Lovell:** "Okay, Houston, we've had a problem here. This is Houston, say again please. Houston, we've had a problem"

NASA mission control & astronauts in the capsule, astronauts safely on aircraft carrier after splashdown

**NARRATOR:** April 1970: Apollo 13. Sparks touch-off an explosive fire more than 200-thousand miles from Earth. Miraculously, after three days in a crippled capsule, the astronauts return safely. The ordeal of Apollo 13 helped prompt research on exactly how fire behaves in zero-gravity.

Skylab in orbit footage, footage of fire tests inside

The first experiments took place in 1974 on the "Skylab" space station. What astronauts discovered was astounding.

**Ross:** "There's simply no up or down in space, so you don't get the tear-drop shape of a candle flame that we see here on earth. Instead, in space, it tends to be all round going in all directions equally."

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| graphic | **NARRATOR:** On earth, warm air rises and cool air is drawn in to replace it from below. These currents, caused by heat and gravity, give flames their distinctive tear-drop shape. In space, flames are round. Without gravity, hot air radiates in all directions instead of rising. |
| NASA film | In the Skylab tests, fires burned erratically. Without the phenomenon of hot air rising, there was no natural current of cool air from below to feed fresh oxygen to the flame.<br><br>**Ross:** "There was always a presumed margin of safety from those very early Skylab experiments. It was always presumed if we tested a material here on earth and it burned a certain way then if we burned that same material in space that it would burn much more slowly or potentially not burn at all." |
| Skylab in orbit | **NARRATOR:** This assumption turned out to be wrong, because the air inside Skylab's fire-test chamber was kept perfectly still.<br><br>**Ross:** "What we have since discovered is that if you have just a little bit of air flow, for example from a ventilation system that's required for the astronauts on board, the fire can be much more robust in fact in space than here on earth." |
| Footage of NASA fire experiments in orbit | **NARRATOR:** Experiments aboard the space shuttle have discovered how droplets of fuel ignite in zero gravity. Heat and particles of soot rapidly spread the fire in every direction. In a pipe or tube, flames can race like a comet. In zero gravity, everyday objects burn in mysterious ways. This is a piece of ordinary paper. |
| inside the space shuttle | These experiments have led NASA to take extreme measures to use specialized fire-proof materials on the Space Shuttle. Even the smoke detectors are special. |

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| Show and tell soundbite with smoke detector in NASA lab | **Ross:** "In our homes we all put the smoke detectors near the ceiling because all the warm air and smoke rise and get into the vicinity of the smoke detector. This device, however, has to have a fan to pull the air into it." |
| NASA shuttle footage in orbit | **NARRATOR:** NASA's fire safety program has paid-off. Several times equipment failures have generated sparks and smoke. However, astronauts have never had to use the fire extinguishers on board. |
| Russian rocket blastoff, Mir in orbit | The Russian space program has not been as fortunate. In February 1997, aboard the space station "Mir," an oxygen-generator malfunctioned. |
| Visual metaphor footage close-up footage of flames from blow torch | **Ross:** "The canister in which it was in, ruptured. And a blowtorch-like flame--fully one and a half feet long--was generated. The crew could not see their hand extended out in front of them roughly one meter away from themselves, so it was a very dense cloud of smoke. They therefore then took extinguishers and simply tried to cool down or wet the surrounding areas to prevent the fire from actually melting a hole through the side of the wall of the Mir." |
| Mir in orbit, exteriors & interiors | **NARRATOR:** The fire lasted 20 minutes. But astoundingly, no one was hurt. |
| earth from space, gas stove in typical household kitchen | Experts are continuing to learn more about fire through experiments in space. This research is making space flight safer. And it's yielding important benefits on earth, such as appliances that create less pollution.<br><br>**Ross:** "Experiments in microgravity, in weightlessness, are in fact the new frontier for researchers trying to understand fires." |
| Dip to black | |
| steel mill hearth, coal power plant aerial | **NARRATOR:** Fire is the foundation of modern civilization. 85-percent of our energy comes from burning fossil fuels. |

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| montage of firefighting footage | As long as we depend on fire, we'll always depend on the fearless individuals who step-in when fire gets out of control. |
| Dip to black | |
| closing credits | |