

# PHYSICAL CONSTANTS FOR INVESTIGATORS

by [Tony Cafe](#)

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At the fire scene the investigator essentially studies the effect of heat on the various materials which survived the fire. From this study, the investigator determines the nature of the fire, its progress from the area of origin and hopefully the cause of ignition. To successfully achieve this goal the investigator needs to refer to the scientific literature for the physical constants of the various materials found at the fire scene because the investigator's conclusions must be reached using a logical and scientific methodology.

The following tables should be of help to the fire investigator in understanding the cause and progress of the fire. The information has been extracted from various sources such as Kirk's Fire Investigation, Cooke & Ide's Principles of Fire Investigation, John N. Cardoulis' The Art and Science of Fire Investigation (1990) and the Fire Protection Handbook. All temperatures are in degrees Celsius and it is noted there exists some discrepancies in the literature of the various physical constants of materials and so the temperatures and constants should be treated as approximates.

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## 1. TEMPERATURES AT FIRES

### 1.1 SOURCES OF IGNITION - GENERAL TEMPERATURES

Source	Temperature (Celsius)
Cigarettes - ventilated	400°-780°
Cigarettes - unventilated conditions	288°
Cigarettes - insulated and smoldering	510°-621°
Match	600°-800°
Candle flame	600°-1400°
Stove element	>550°
Fluorescent light	60°-80°
Incandescent light	100°-300°
Tungsten halogen light	600°-900°
Electrical arcing	to 3750°

Electrical spark	1316°
Lightning	30000°
Oxyacetylene	3300°
Industrial furnaces	1700°
Bunsen burner	1570°

### 1.2 COLOR TEMPERATURES OF HEAT

Dull red	500°-600°
Dark red	600°-800°
Bright red	800°-1000°
Yellow red	1000°-1200°
Bright yellow	1200°-1400°
White	1400°-1600°

### 1.3 TEMPERATURES DURING BUILDING FIRES

Hot gas layer	600°-1000°
Floor temperature	>180°
Glowing smoldering combustion	to 600°

Flashover	>600°
Glowing coals	to 1300°

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## 2. PHYSICAL CONSTANTS OF MATERIALS

### 2.1 SOLIDS

#### 2.1.1 VARIOUS MATERIALS

<i>Reactions to temperature exposure</i>	
<b>Reaction</b>	<b>Temperature (Celsius)</b>
Wood slowly chars*	120°-150°
Decayed wood ignites	150°
Ignition temp of various woods	190°-260°
Paper yellows	150°
Paper ignites	218°-246°
Oil soaked lagging ignites	190°-220°
Leather ignites	212°
Hay ignites	172°

Coal ignites	400°-500°
* wood chars at a rate of approximately 30-50 mm/hour	

### 2.1.2 PLASTICS

<i>Melting points and ignition temperatures</i>		
<b>Plastic</b>	<b>Melting Point Range</b>	<b>Ignition Temperature</b>
ABS	88°-125°	416°
Acrylics	91°-125°	560°
Cellulosics	49°-121°	475°-540°
Nylons	160°-275°	424°-532°
Polycarbonate	140°-150°	580°
Polyesters	220°-268°	432°-488°
Polyethylene ld	107°-124°	349°
Polyethylene hd	122°-137°	349°
Polypropylene	158°-168°	570°
Polystyrene	100°-120°	488°-496°
Polyurethanes	85°-121°	416°

PTFE	327°	530°
P.vinylidenechlor	212°	454°
PVC	75°-110°	435°-557°
Wool		228°-230°
Cotton		250°
Rubber		260°-316°

### 2.1.3 METALS

<i>Melting points and flame colours</i>		
(o) & (r) denote oxidizing and reducing conditions respectively		
<b>Metal</b>	<b>Melting Point</b>	<b>Flame Colour</b>
Aluminium	660°	Colorless
Copper	1080°	Green (o) Red (r)
Lead	327°	Colorless
Tin	232°	Colorless
Bismuth	271°	Colorless
Zinc	419°	Colorless

Aluminium alloy	600°	Colorless
Antimony	630°	Colorless
Magnesium	651°	Colorless
Brass	900°-1000°	Green (o) Red (r)
Silver	961°	Colorless
Bronze	1000°	Green (o) Red (r)
Gold	1063°	
Cast iron	1200°-1350°	Yellow-brown
Manganese	1260°	Violet (o)
Nickel	1450°	Brown-Red
Cobalt	1490°	Blue
Steel	1100°-1600°	Brown-Red
Platinum	1770°	
Titanium	1670°	
Chromium	1900°	Green
Tungsten	3410°	
Solder 60/40	183°	

Electric fuses	371°	
Carbon	3730°	
Pure iron	1535°	

## 2.2 LIQUIDS

<i>Boiling points, flash points, ignition temperature and heat of combustion</i>				
<b>Liquid</b>	<b>Boiling Point</b>	<b>Flash Point</b>	<b>Ignition Temperature</b>	<b>Heat of Combustion (kilocalories per gram)</b>
Kerosene	175°-260°	38°-74°	229°	11
Gasoline	40°-190°	-43°	257°	11.5
Stove oil	190°-290°			
Diesel	190°-340°	69°	399°	
Fuel	200°-350°			
Brake fluid		190°		
Engine oil		150°-230°	260°-371°	
Acetone	57°	-20°	465°	
Benzene	80°	-11°	560°	10

Octane	126°	13°	220°	11.4
Pet ether		-18°	288°	
Gum turpentine		37°		
Spirit turpentine	135°-175°	35°	253°	
Alcohol	78°	13°	365°	7.1
Ethylene glycol		111°	413°	
Styrene		31°-37°	490°	
White spirits	150°-200°	35°	232°	
Asphalt		38°-121°	538°	
Paint thinners		39°	245°	
Paraffin wax		199°		
* fire point is approximately 10°-50° above flash point				
* cooking oil spontaneously combusts at 310°-360°				
* temperature of flame from burning petrol is 471°-560°				

## 2.3 GASES

*Upper & lower flammable limits & ignition temperature*

Gas	UFL %	LFL %	Ignition Temperature
Propane	9.6	2.15	466°
Butane	8.5	1.9	405°
Natural gas	15	4.7	482°-632°
Hydrogen	75	4	400°
Acetylene	3	65	335°

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### 3. TEMPERATURE INDICATORS

#### 3.1 STEEL

Appearance	Temperature
Yellow	320°
Brown	350°
Purple	400°
Blue	450°
* steel starts to weaken at 200°	

\* loses 50% of its structural strength and sags at 550°

\* melt point of steel 1100°-1650°

### 3.2 CONCRETE AND CEMENT

Appearance	Temperature
Reddish pink - reddish brown	300°
Gray	300°-1000°
Buff	>1000°
Sinters and yellowish	>1200°
* sand and sandstone becomes friable at 573°	
* wall masonry collapses at 760°	

### 3.3 GLASS

Effect	Soda	Borosilicate
Very slight distortion	700°	750°
Slight distortion	750°	800°
Considerable distortion	800°	850°
Medium fluid flow	850°	900°

Liquid flow	900°	950°
* glass thermally cracks at 90°-120°		

### 3.4 MINERAL WOOL INSULATION

Effect	Temperature
Resin chars & slowly blackens	288°
Resin chars quickly	400°
Fibers becomes light gray	482°
Fibers fuse	593°
Fibers melt	649°

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## 4. FIRE CAUSES

### 4.1 ACCIDENTAL FIRE CAUSES

- Defective or left on heating or cooking equipment
- Defective chimney or flue
- Hot ashes or coals
- Combustibles near heaters
- Smoking or matches
- Electrical
- Rubbish fires
- Chimney or bushfire sparks on roof
- Welding and cutting
- Friction sparks from clashing metals
- Overheating of machinery
- Candles
- Poor storage of flammable liquids
- Lightning
- Children and matches
- Spontaneous ignition
- Gas and gas appliances

#### **4.2 ARSON INDICATORS**

- Presence of flammable liquids
- Multiple points of origin
- Use of trailers, timing devices
- Presence of explosion
- Sign of forced entry
- Sign of contents removed before the fire or replaced with inferior goods
- Signs of tampering with gas or electric appliances or sprinklers
- Signs of artificial drafts eg holes in walls
- Rapid onset of fire, higher than normal temperatures closet fires
- Other crime committed

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