Tuesday, 19 June 2018
(10.00 am)
SIR MARTIN MOORE-BICK: Good morning, everybody. I'm going to invite Mr Kinnier to take matters up from here.
MR KINNIER: Thank you, sir.
Before I start, there's a housekeeping announcement. There is no planned fire alarm today. If the fire alarm sounds, trained fire wardens on the second floor will direct everyone to evacuate. There are two fire exits within this room on the right-hand side facing the chairman. Holborn Bars staff and the inquiry team will ensure that everyone is evacuated first before they evacuate the building.
Finally, may I ask everyone to turn their phones off or to silent during the course of the hearings.
Sir, turning to today, we have a presentation from Professor Niamh Nic Daeid, which will cover three essential topics: first of all, the basic science of fire; secondly, the elements of fire investigation; and, finally, a summary of Professor Nic Daeid's preliminary views on the cause and origin of the initial fire within flat 16.
SIR MARTIN MOORE-BICK: Thank you.
MR KINNIER: Before I call Professor Nic Daeid, I should repeat yesterday's warning regarding the content of the

presentation. It contains not only photographs of flat 16, ie the burnt-out compartment, but also video images which show the early development of the fire, as well as thermal images of the firefighting within flat 16 itself. Also, there will be a playing of Mr Kebede's 999 call during the course of the presentation. The images and audio may, therefore, be distressing.
With that, sir, may I now call Professor Nic Daeid.
SIR MARTIN MOORE-BICK: Yes, thank you.
PROFESSOR NIAMH NIC DAEID (affirmed)
SIR MARTIN MOORE-BICK: Thank you.
MR KINNIER: Thank you. Would you prefer to stand or sit?
PROFESSOR NIC DAEID: I prefer to stand, thank you.
MR KINNIER: First of all, what is your name?
PROFESSOR NIC DAEID: My name is Niamh Nic Daeid.
MR KINNIER: You are professor of forensic science in the University of Dundee?
PROFESSOR NIC DAEID: That is correct.
MR KINNIER: You are director for the Leverhulme Research Centre for Forensic Science?
PROFESSOR NIC DAEID: That's correct.
MR KINNIER: You're a chartered chemist?
PROFESSOR NIC DAEID: Yes, I am.
MR KINNIER: You are the immediate past chair of the

European Network of Forensic Science Institutes working group on fire and explosion investigation.
PROFESSOR NIC DAEID: That's correct.
MR KINNIER: And you are the deputy chair of the scientific advisory board of the International Criminal Court?
PROFESSOR NIC DAEID: Yes, I am.
MR KINNIER: You are also a fellow of the Royal Society of Edinburgh?
PROFESSOR NIC DAEID: Correct.
MR KINNIER: The Royal Society of Chemistry, the Institute of Chemistry of Ireland?
PROFESSOR NIC DAEID: Yes.
MR KINNIER: You are a fellow of the Royal Statistical Society?
PROFESSOR NIC DAEID: Correct.
MR KINNIER: And, finally, you're a fellow of the Chartered Society of Forensic Science?
PROFESSOR NIC DAEID: That's correct.
MR KINNIER: It's right that you provided the inquiry with a preliminary report dated March of this year?
PROFESSOR NIC DAEID: Yes, I did.
MR KINNIER: And you've provided the report in the same way as you would provide a report as if you are in court?
PROFESSOR NIC DAEID: Yes, I did.
MR KINNIER: And as to the factual matters set out in the

report, they are true to the best of your knowledge and belief?
PROFESSOR NIC DAEID: They are.
MR KINNIER: Finally, does your report accurately set out your opinion on matters relevant to the inquiry?
PROFESSOR NIC DAEID: Yes, it does.
MR KINNIER: Professor Nic Daeid, with that, may I invite you now to give your presentation.
PROFESSOR NIC DAEID: Thank you.
SIR MARTIN MOORE-BICK: Thank you.
PROFESSOR NIC DAEID: Good morning.
By way of an initial introduction, I have been tasked specifically to address matters relating to the determination of where within Grenfell Tower on 14 June 2017 the fire started, and how the fire started within this location. This is known as an origin and cause determination within the fire investigation process, and it is one of the primary objectives of the examination of a fire scene by fire investigators.
As an expert witness for the Grenfell Tower public inquiry, it is my responsibility to provide, to the best of my ability, my impartial, honest and unbiased opinion based on known and verifiable information relating to the events which occurred in the early hours of 14 June 2017.

My presentation will be in four parts.
Firstly, I will provide a brief introduction about my terms of reference, and then some information about how I went about fulfilling these terms of reference as my part of Phase 1 of the public inquiry.
Secondly, I will provide an overview of what is fire, how a fire starts and how a fire develops in a room. My reason for providing this information is to try to ensure that everyone can understand what is needed in terms of both the physical evidence and the information obtained from witnesses in order to provide a reliable determination of the area of origin, that is the place where a fire started, and also to understand the sequence of events that have to be demonstrated scientifically in order to have confidence in the determination of the cause of a fire.
Next, I will provide an introduction to fire scene investigation and to how that process is undertaken. This will help in understanding the purpose of a fire investigation, the actions of the fire investigators and the potential limitations of their conclusions. I will explain how a fire investigation is usually undertaken, and what fire investigators will do in practice and how they reach their conclusions.
Finally, I will provide my preliminary

interpretation of the available evidence relating to the origin and the cause of the fire that occurred in Grenfell Tower on 14 June 2017. This is based on the information presented in the materials that I have received in my role as an expert witness for the Grenfell Tower public inquiry.
Experts will often use words that are full of jargon and, while these may be understood by other experts, they may leave non-experts and members of the general public feeling that they do not understand what is being said to them. I am going to use as little jargon as possible, and I will try to explain the concepts clearly and in straightforward language so that everybody can follow what I'm saying.
During the final part of my presentation, I will be speaking about the early stages of the fire in Grenfell Tower which occurred on 14 June 2017. I will play part of the initial 999 call made by Mr Kebede and I will be showing pictures of the fire and its aftermath within flat 16.
I will also be showing some of the thermal imaging video footage taken by the first firefighters who entered flat 16, as well as some videos of the incident from the outside of the building during these early stages of the fire's development. These will be shown

on a split screen, side-by-side, so that the activities of the firefighters are put into context with the development of the fire.
I will provide a warning prior to playing the audio of the 999 call and also to showing the photographs and the video.
I was instructed as an expert witness to the Grenfell Tower public inquiry on 6 November 2017. As an expert witness in this context, it is my responsibility to provide an opinion relating to the questions asked of me within my terms of reference, and to do so impartially and objectively based upon the information made available to me by the public inquiry team. In this role, I have an obligation and a duty to provide assistance to the public inquiry in relation to issues which have been asked of me and which are specifically within my areas of expertise.
My terms of reference cover two specific questions.
Firstly, I was asked to review where in Grenfell Tower the fire started and what the cause of the fire was within that area of origin.
Secondly, I was asked to review how the fire spread through the compartment of origin and through the flat of origin.
At the time of preparation of this presentation and

of my Phase 1 provisional report, the police investigations relating to the fire at Grenfell Tower are still ongoing. As such, the conclusions I express at this stage can only be provisional and I will update my report as new information is made available to me.
Where the evidence that has been made available to me has allowed, then my opinions have been made on the balance of probabilities; that is where something is more likely than not to have happened.
If I cannot reach a reliable conclusion based on the information provided to me at the point of preparation of my Phase 1 provisional report, then I have made this clear within the report.
I undertook two visits to Grenfell Tower as part of my work. These visits were facilitated by the Metropolitan Police Service, to whom I am very grateful.
The first visit was on 9 October 2017. On this occasion, I visited Grenfell Tower with some of the other experts to the public inquiry and some of the public inquiry legal team. I went into many of the flats within Grenfell Tower and I gained a strong perspective of the building and of the level of damage and destruction within the flats on different floors of the building. I went from the ground floor of the building to the top floor of the building and out onto

the rooftop of the tower.
During this visit, I had an opportunity to visit flat 16 specifically and spend some time in the remains of that flat.
My second visit to Grenfell Tower was on 9 November 2017. On this occasion, I spent time in each of the flats on the fourth floor of Grenfell Tower and, in particular, within the remains of flat 16.
At the time of both of these visits, much of the furnishings and the debris remaining after the fire within flat 16 had either been removed or had been placed in bags awaiting removal. All of the electrical appliances and some of the electrical wiring had also been removed by this time.
As a consequence, little of the items visible in the photographs that I have used in my Phase 1 provisional report were present in flat 16 at the time of my two visits to the property. As a consequence of this, the photographs and the notes made by the fire investigators who undertook the initial scene investigation became my primary source of information.
These initial investigators were members of the London Fire Brigade investigation team, who were the first team on site. They were subsequently joined by fire investigators from Bureau Veritas, which is

a company which supplies scientific support to the London Fire Brigade, and they were also accompanied by fire investigators from Key Forensic Services Limited, which is a private company which supplies forensic science services to police forces and to other clients.
I was provided with fire investigation reports, notes and photographs prepared by the Bureau Veritas and Key Forensic Services fire investigators. I was also provided with witness statements from the occupants of flat 16 and from London Fire Brigade personnel. I also viewed videos provided by members of the public and by the London Fire Brigade.
Undertaking a review of a fire investigation is not an ideal circumstance. In such a circumstance, the methodology followed by the initial investigation team becomes very important, as does the quality and the completeness of the information recorded, specifically through notes, photographs and witness statements of what the investigators saw and what actions they took. Such records and information are needed so that all relevant evidence was identified, was correctly recorded in its original position, was correctly recovered and is accounted for in the examiner's notes of their observations and their actions.
The actions of the fire investigators, their

observations and how they undertook their investigation are recorded in their investigator notes. These are called contemporaneous notes, which means that they were made at the time of or shortly after the time that the activities occurred. They are often handwritten notes, as well as photographs and sometimes video materials.
In the second part of my presentation, I will provide some background information about what a fire is, about how things burn and what needs to be in place in order for that burning to occur. This will include the steps needed so that a fire can start and how, once started, a fire develops within a contained space such as a room in a flat.
Understanding how fires start and how they develop is underpinned by robust chemical, physical and engineering principles, and there is much peer reviewed scientific literature and engineering literature, textbooks and other materials that are devoted to this topic.
This provides an accepted rigour and confidence in the understanding of the conditions that are required for materials to ignite and for any resultant fire to develop and to spread. Such processes are well-accepted and considered reliable across the experts in the field and are described generally as fire dynamics.

My explanation of these processes will be very general so as to simply provide an overview. Some of my fellow experts may explain some of the concepts that I introduce to you in greater depth and detail during their evidence.
When a fire occurs, there will often be physical materials remaining after the event, and I will explain some of the common types of fire damage that can occur and what hypotheses can be inferred from the damage by the fire investigators.
In order for solid or liquid materials to burn, they must first be turned into a gas. This process requires the material to be heated. Materials contain atoms which are linked or bonded together to other atoms to make molecules and all combine together to make up the material itself. The most common materials are called hydrocarbons and they contain atoms of carbon and of hydrogen, as well as a variety of other elements depending on the material itself.
I have represented this in this diagram. The white circles and red circles represent the atoms, and the black lines represent the bonds between the atoms.
When hydrocarbons are heated, energy is transferred to the material and this energy causes the bonds or the links between the atoms to break or to decompose. This

decomposition process is called pyrolysis, and it requires a source of heat in order to occur.

Materials will then change chemically when they are heated in a process that is called thermal decomposition. The materials can also change physically; for example, a liquid is turned into a gas, or a solid is turned into a gas, leaving behind a solid residue and ash.

The pyrolysis process is complicated and the composition of the gases coming from the materials and the mixtures can, as a result, also be a complex and sometimes toxic mixture. This mixture will depend on the heated material and what it was made of, and also the temperature to which it was heated.

The pyrolysis process is fundamentally related to the temperature that the materials are exposed to and to the amount of heat energy required for the pyrolysis to occur, which is different for different materials. For example, plastics tend to pyrolyse at higher temperatures than materials such as wood.

Pyrolysis and the generation of pyrolysis products is the first step in the combustion or the burning process.

When the gases produced as a consequence of the pyrolysis process are mixed with oxygen, which I have

represented in blue in the diagram -- this oxygen comes from the air -- when this mixture is in the right percentages then combustion can occur. Combustion is a chemical reaction which generates heat, which is represented by the downward yellow arrows in my diagram. Combustion also generates light and it generates combustion products.

There are different types of combustion, which include smouldering combustion, where a flame is not visible, and flaming combustion, where flames are visible. Pyrolysis and combustion typically also produce smoke, which is formed by small airborne particles of soot, of ash and of liquid, and these products move away from the material that is burning and that produces them. As they cool down, they can settle onto vertical and horizontal surfaces as black, sooty deposits.

Flaming combustion, which is what we recognise as a fire, has a number of essential requirements:

(1) There must be a localised heating of a combustible material, where a combustible material, otherwise known as a fuel, is one that can ignite and can burn.

(2) This localised heat must have enough energy so that the fuel undergoes pyrolysis and generates gases.

(3) Oxygen must be present in the environment of the gases, such that it mixes with the gas. In some cases, the gasses from the fuel and oxygen are premixed, but more often the oxygen moves into the gaseous fuel in a process which is called entrainment. Not all gaseous fuel and air mixtures can sustain a flame and those which can are called flammable mixtures.

(4) Some means of ignition needs to be present in the environment of this fuel-air mixture which has enough energy to ignite the mixture.

(5) Finally, the fuel and oxygen interact in a self-sustaining, heat-producing chain reaction, which facilitates further pyrolysis of nearby combustible materials and so prolongs burning.

These requirements are often referred as to the fire triangle or fire diamond. All three elements of the fire triangle -- that is heat, oxygen and fuel -- must be present for the fire to be sustained, and if any of these elements are removed, then the fire will simply extinguish.

Fires can switch between smouldering and flaming combustion and in many circumstances flaming fires will follow an initial period of smouldering combustion and a smouldering combustion phase will occur towards the endpoint of a fire.

Ignition is the start of a sustained burning event. There are two types of ignition: piloted ignition, where an external ignition source, such as an independent flame, is used, and autoignition, where the fuel-air mixture is raised to sufficient temperature that it will ignite of its own accord.

Small flames, such as those associated with candles, are called laminar flames, where a high temperature zone usually exists, generally around 800 to 1,400 degrees centigrade, and it exists around the flame and can be maintained. This allows for the almost complete combustion of the small particles of carbon or soot generated as byproducts of the pyrolysis process, and this almost complete combustion produces the colour that is seen in the candle flame and it is why candles do not produce very much smoke.

As the flame begins to become larger or more disrupted, the soot particles begin to escape unburnt from the high temperature zone around the flame and form a large part of the smoke that is seen during flaming combustion. These larger and more ragged flames are known as turbulent flames, with an average temperature of approximately 1,000 degrees centigrade.

To understand how an initial material on fire leads to the development of a fire in, for example, a room, we

need to think of how the heat generated by the initial fire begins to affect the materials that are nearby, and for the development of fires relies upon the movement or transfer of heat from one material to another. This will be determined by the ability of the material once it is on fire to release heat energy. This ability is called a heat release rate. The rate at which heat energy can be transferred to a material is called the heat flux.

More formally, the heat release rate is defined as the amount of heat energy that is released by a material per unit time, which is usually a second, when that material is on fire. The heat flux is the rate at which heat energy can be delivered to a material per unit area per unit time.

The transfer of the heat energy released from a material when it burns on to nearby materials can occur in a number of ways. Understanding the methods of heat transfer are very important, so that the way in which a fire can move between nearby materials can be explained.

Heat transfer explains how a fire can move from one item to the next and how a fire grows and develops within, for example, a compartment.

There are three heat transfer mechanisms:

(1) Conduction is the transfer of heat energy between adjacent chemical molecules and electrons within a material. An example would be holding the handle of a pot that is heating on a stove. The handle you are holding becomes hot and that is because heat is being conducted through the metal of the pot.

(2) Convection. Convection is the transfer of heat through the movement of heated liquid or gas. An example of this would be the water in the pot heating up.

(3) Radiation. Radiation is the transfer of heat in the form of electromagnetic radiation. An example would be the heat that you feel coming from the hot plate that the pot is resting upon.

Heat can also be transferred directly through a flame interacting with a surface. This is called direct flame impingement. This is where a flame comes into direct contact with a new fuel source and provides both the heat source for pyrolysis to occur and the ignition source for those pyrolysis products, once they mix with oxygen, to ignite.

The sequence required for a material to burn follows a very defined pathway.

Firstly, there needs to be localised heat focused for long enough in area where there are materials that

can combust so as to generate the pyrolysis products.

Secondly, the generated gases need to mix with oxygen in the air and an ignition source is required so that the ignition can occur and the material then burns. This generates more heat, pyrolysing further fuel so that the combustion reaction becomes self-sustaining.

As a fire burns, it creates a rising column of gases, which are called a fire plume. Hot gases are buoyant, which means that they rise upwards into the air. The fire plume can generally rise quickly and it can rise to considerable heights above the flame. This is why if you hold your hand some distance above a candle flame, you can still feel the heat from the candle. What you feel are the buoyant hot gases of the candle flame.

Cooler air will circulate into the flame and replace the hot gases, and this is a process that's called air entrainment. When the hot gases produced by a fire meet a horizontal surface, such as a ceiling, these gases can spread out along that surface in what are called ceiling jets.

The resultant ceiling jets act themselves as a source of further heat. They radiate heat back into the room, and this heat will now begin to affect nearby materials by transferring heat energy into those

materials, causing pyrolysis and the thermal decomposition process to occur.

As the pyrolysis gases begin to emerge, mixing with air to form a flammable gas mixture, they are readily ignited by nearby flames and the fire begins to grow and begins to develop.

Within a compartment, this process occurs in the same way. A localised heat source will pyrolyse combustible materials. These will release gases, which mix with air and are ignited. This creates a fire plume of buoyant gases, which rises to the ceiling and spreads out along the horizontal surface. Air will entrain into the buoyant gases.

From this point, fire development within a compartment, if left unchecked, will follow also a well-defined series of stages once flaming combustion has been established.

In the early stages of a fire, the sequence of events for each item of fuel within a compartment to begin to burn are essentially the same.

Once combustion of the first fuel item begins, the fire plume increases in height and begins to have an effect on combustible materials nearby, through the different heat transfer mechanisms.

The buoyant hot gases in the fire plume begin to

spread out at ceiling level, creating a layer of hot gas and smoke in the room which radiates heat back into the entire room as this layer spreads out horizontally and begins to descend vertically. This causes other combustible materials to thermally decompose, to produce pyrolysis products, to mix with available oxygen and to ignite. Direct flame impingement may also occur.

The hot gas layer in the room begins to get bigger as more materials become involved in the fire and start to burn. The main heat transfer mechanism in the room becomes radiant heat from the gas layer. This radiated heat energy would begin to be transferred to all of the combustible materials within the compartment, raising the temperature of these materials so that pyrolysis will begin.

The boundary between the hot gas layer and the lower portion of cooler air in the room is known as the neutral plane, and it can change and descend as the fire progresses and creates more hot gases and smoke.

If flames reach up into the hot gas layer then the temperature of the gas layer can increase and so the amount of heat energy transferred into the room via radiated heat will also increase. There may come a point where all of the exposed combustible material surfaces within the compartment will begin to produce

enough gaseous products such that they will ignite and become involved in the fire.

This event is called flashover. Flashover can be thought of as the point in a fire where a room becomes fully involved, and where all combustible materials within that room are burning.

After flashover, the fire will burn steadily and will begin to decay as the fuel is used up or upon intervention by, for example, the Fire Brigade.

Very many things will affect how fires develop within enclosed spaces and the speed of this development. These include, but are not limited to, what the combustible materials present are made out of, and how quickly they go through the process of pyrolysis, production of gas, mixing of that gas with air and then ignition.

The heat energy that they transfer into the space once ignited, the presence of oxygen, the position of the fuel in the compartment and the dimensions and the characteristics of the compartment, as well as many other factors, are important.

As a result, fires in compartments, once ignited, can develop across a wide range of time frames. The early stages of a fire are considered to be fuel-controlled; that means that the size of the fire is

controlled by how much fuel is burning and how much heat energy that fuel releases, and the position of that fuel in the compartment, assuming that sufficient oxygen is present. If the rate of burning begins to exceed the amount of air coming into the room, then the fire becomes ventilation-controlled.

In my next slide, I am going to show some photographs of an item that is on fire. These images are not associated with the fire at Grenfell Tower and I am using them only to illustrate the importance of the location of fuel within a compartment and the effect that this location can have on the speed to flashover.

The location of materials -- for example, if an item is located in the middle of a room, or against a wall, or in a corner -- can have a significant effect on the speed with which a fire can develop within that compartment.

When a fire is confined against a wall or in a corner, the flame associated with the combustion of the item will extend in its height to ensure that enough oxygen can entrain into the flames in order that the material can combust and combustion can be sustained.

The photographs I am going to show you are of a fire test where the same item -- a cushion -- is placed in the middle of the room in the first test, against the

wall in the second test and in a corner for the third test.

In the first situation, the flames are relatively small in height, and that is because the air can come into every side of the exposed flame to support the combustion of the fuel.

In the second test, the cushion is now up against a wall. The airflow, as a consequence, is more restricted, and as a consequence the flame grows in height so that the combustion can be maintained.

When the airflow is restricted even further, by placing the fuel in a corner, the flames now extend right up into the ceiling which, in turn, heats up the gas layer to a greater extent and more quickly. This will increase the amount of radiant heat energy coming back into the space so that other materials nearby would be expected to become involved in the fire more quickly.

This shows that even though the material which is burning is essentially the same, the location of the fuel can have a significant impact on the fire's development.

Generally speaking, the movement of smoke and hot gases through a compartment will dictate the movement of the fire as the hot gases and smoke transfer heat to nearby materials.

When fires occur, there can be a significant impact to the structures and materials within the environment of the fire and beyond. Understanding the physical effect of a fire on materials is critically important, and it is this understanding that is used in interpreting the damage after a fire has occurred. This enables fire investigators to try to reconstruct the story of the early stages of the event.

Most materials will respond to a fire in a predictable way. This will depend upon the physical and chemical properties of the material, and on what the material essentially is made out of; for example, different types of plastics, wood, glass, concrete, metals and so on will all experience heat differently.

The effects of fire on materials may include also, for example:

The damage to the structure of the material, such as melting of glass or metal, or the breaking apart of concrete or brick, which is a process called spalling.

The way in which the soot and smoke is deposited on vertical or horizontal surfaces or areas where deposition is absent is important.

The effect of heat on some surfaces which can lead to changes in the colour and the texture of those surfaces, for example the removal of water from gypsum

wall boards as a result of heat, a process called calcination, causes a physical change in colour and competition of that material.

The oxidation of surfaces can also cause their colour to change. For example, copper can turn red or black.

A change in colour can also occur because the fire has removed corrosion protection, such as paint, on a material and so the materials underneath will oxidise or, as otherwise known, rust.

The melting of materials, which would occur at known temperatures or known temperature ranges.

The charring or burning of materials can generate specific patterns, which are called burn patterns. These are patterns which can provide indications of an area that was burning for longer than others or where burning was more intense because of the type of material present or because of its location or because of other effects, such as ventilation.

The combination of these different indicators that I have mentioned, and others, form the fire patterns within a fire scene.

A fire pattern is a general term which describes many different types of physical evidence that may be observed within a fire scene. The effects of the fire

on materials present in the fire scene are used to define these fire patterns. As such, they are formed by heat, by smoke deposition and by the burnings of materials.

Fire investigators will use these patterns, combined with a knowledge and understanding of the relevant scientific, engineering and fire science literature, as one of the tools to help them to attempt to understand the history of the fire, so as to identify the area of origin and to contribute to the determination of the cause of a fire, if indeed this is possible.

As such, fire patterns in part act as a narrative for the fire's origin and development. Patterns are analysed by the fire investigators in combination with each other, and with other information available, for example from witness statements or from the electrical system in a property.

Fire patterns can occur sequentially, one after the other, and, as a consequence, they can overlap each other as the fire develops. This is particularly true in the latter stages of a fire's development or where a fire may have flashed over, as the early fire patterns can be destroyed or can become obscured.

Fire patterns can also be used to identify areas where the fire was burning intensely, as well as

providing information that might explain how the fire moved from one place to another.

When the fire plume interacts with vertical and horizontal surfaces, one of the types of fire patterns that can result is known as a V or a U-shaped pattern. These are patterns created when soot or smoke condenses onto a vertical surface to leave marks in the shape of a V or of a U.

After the fuel is ignited and a flaming fire develops, the fire plume comes into contact with the wall. As this is a cooler surface, soot and smoke will condense onto that surface. This can form visible black patterns on the wall in the shape of a V or a U, as I said. The shape of the patterns can change if there are openings such as windows which can change the direction of the smoke.

These patterns form in a three-dimensional space, and often a pattern will also form on the ceiling, to give the shape of a cone in three dimensions. If the fire continues in this area then the deposited smoke can also be burnt back off to leave a clean area within the original pattern, for example in this case on the ceiling, and this is called a clean burn.

V-shaped patterns can sometimes indicate areas where the fire has been burning for longer, which can provide

some evidence of a possible area of origin of a fire.

Other fire patterns can be built up as a combination of both the burning of materials and of smoke deposition.

Areas where the damage to materials is more pronounced can indicate where a fire has been burning for longer periods of time or more intensely. This is very dependent on the types of materials and so such physical evidence should be considered cautiously.

Low-level burning or charring, for example on floors or on skirting boards, can indicate an area where the fire may have burnt lower than elsewhere, and can possibly be indicators to a potential area of origin.

In this example, there are three fire effects that make up the fire pattern: firstly, the V-shaped mark, which is a smoke pattern on the wall which occurs as smoke condenses onto the wall as the fire plume develops; secondly, a burn pattern on the floor, where the fuel which was burnt was located; finally, a burn mark on the skirting board.

All three of these marks combined together suggest a fire that may have been at floor level and burning for long enough to create the damage to the floor and to the skirting board.

This finishes the first part of my presentation.

SIR MARTIN MOORE-BICK: Thank you.

MR KINNIER: Sir, that might be a convenient place to take a break.

SIR MARTIN MOORE-BICK: Yes. Very well, then, we'll have a short break now and resume at 11.05, please.

Thank you.

(10.50 am)

(A short break)

(11.11 am)

MR KINNIER: Thanks, sir. Professor Nic Daeid will continue with her presentation.

SIR MARTIN MOORE-BICK: Yes, when you are ready.

PROFESSOR NIC DAEID: Thank you.

I now want to turn to the third part of my presentation, which is relating to the process of how a fire scene is investigated.

Fire investigations are, by their nature, destructive of the fire scene that is being investigated and will often involve the removal of debris in layers, where items and materials are moved, or in some cases removed, from the scene for further examinations as the investigation progresses. As a consequence, the investigation of a fire scene should be planned, it should be systematic and it should be methodical. Evidence within fire scenes can be misinterpreted. They

can be lost or destroyed if the process is not undertaken carefully.

In the UK, we have a code of practice for investigators of fires and explosions for the criminal justice system, which provides details of the objectives and the mechanism of fire scene investigation.

All observations and actions should be comprehensively recorded, both photographically and in contemporaneous notes written at the time of the examination.

Materials and items within the scene should be documented in place where they are found so that their exact location is recorded and is known. Knowing the exact position of items relative to each other prior to the fire helps in piecing together the sequence of events which may have occurred.

Fire patterns -- for example, burning, charring, or discolouration -- that may be associated with the different items present in the scene should also be noted and should be documented, and only when the scene has been initially documented should items begin to be moved around. Once the item has been documented where it was found, the item can be carefully moved, placed into appropriate packaging and the packaging sealed before removal from the scene.

The recovery and removal of items should be undertaken in such a way as to preserve the item as much as possible. This can be challenging, particularly with fire-damaged objects as they can be very fragile as a consequence of the fire event.

Timely recovery of materials is also important as materials can deteriorate considerably if left within a fire scene for prolonged periods of time.

Sometimes items recovered from fire scenes are taken to a laboratory for further examination. This is often the case for electrical items or for electrical appliances, or for fire debris which is thought might contain a liquid accelerant, for example. Such laboratory examinations should be undertaken in a clean laboratory space following standard procedures.

Again, items should only be examined systematically and all examinations must be fully documented.

Laboratory examinations usually involve an initial, non-destructive visual examination. This can sometimes involve using a microscope to look at fine details or using other techniques such as X-rays. Again, these laboratory examinations should involve recording in detail the damage observed on the items.

There are other examinations as well that can be undertaken which provide more in-depth understanding of

what might have happened to the item. This depends upon the investigative need. These other examinations can be destructive of the materials that are being tested.

The main objectives of fire scene investigation include:

(1) Identifying where the fire started. This is the area of origin. This is an assessment made by a fire investigator based on the available evidence and can involve some subject assessment of that evidence.

(2) Identifying the specific cause of the fire, if it is possible to do this.

(3) Fire investigations also often involve determining how the fire might have spread, both within a compartment and from that compartment to elsewhere in the building.

The way in which a fire develops, what materials become involved, the location of these materials at the time of the fire, how the smoke and combustion products move within a compartment and between compartments, whether doors and windows are open or are shut, and many other factors within a fire scene, can be hypothesised upon based on the physical evidence that survives the fire and remains at the scene after the fire has been extinguished.

It is generally accepted within the fire

investigation community that the determination of the area of origin of a fire involves the interpretation of information derived from four main elements, and these are:

(1) Fire patterns. This involves the systematic examination of the various physical evidence and patterns that remain within the structure which occur as a consequence of the interaction of the fire with that structure and with the materials that may be present.

(2) Electrical surveys. This involves the examination of the physical damage within and to electrical items occurring as a result of heat and direct attack by the fire. This involves understanding how electrical systems work and understanding how electrical appliances work, what common faults may occur in different appliances and whether these faults are themselves capable of causing a fire. Such examinations may require the expertise of a specialist fire electrical engineer.

(3) Fire dynamics. This is an understanding of how fires start, how they spread and how they develop within a fire scene and is informed by laboratory experiments and the scientific and engineering literature, textbooks and so on relating to fire science and fire engineering.

(4) Witness statements and materials which can

provide vital early information about, for example, where items were located at the time of the fire; who called the fire and rescue services; whether any sights, sounds or smells were observed prior to the fire or during the early stages of the fire; what video or CCTV material may be available, and so on.

In some fire scene investigations, portions of the scene may be gridded off so that different areas can be examined systematically and sequentially. In these situations, the recovered debris within each grid would be searched independently of all other gridded areas and the work undertaken would be recorded and fully documented. It would not be unusual for the materials within a gridded area to be recovered together and searched more carefully within, for example, a laboratory.

In some cases, where the use of an ignitable liquid, for example petrol, are suspected in efforts to accelerate the fire, samples may be recovered from the fire scene and subsequently analysed in a laboratory for the presence of those chemicals, which would possibly indicate the presence of such an ignitable liquid. Hydrocarbon detection dogs, trained in the detection of residues of ignitable liquids, may also be used during the fire scene investigation.

Once a room has been cleared of fire debris, it is often valuable to relocate some items back into the positions that they were in at the time of the fire. In many cases, this can be done quite successfully using the fire patterns within the scene as a guide.

By reviewing witness statements and other evidence -- for example, CCTV footage -- as well as fire patterns and physical evidence, including, if appropriate, the relocation of items into their original positions at the scene, it may be possible to identify the area of origin of that fire.

It is often stated that fire scene investigation should follow what is called a scientific method. This presents a systematic data collection and data analysis process followed by the development of various hypotheses which are tested against that data, and a final hypothesis is chosen.

Initially, the purpose of the fire scene investigation needs to be identified, as this allows for the initial strategy to be developed in terms of setting the priorities for the investigation.

Fire scene investigation is primarily a subjective process where the investigators will collect data using their experience, their knowledge and their understanding to interpret the physical evidence that's

provided through fire patterns and, if relevant, the electrical evidence remaining at the fire scene. This is then placed in the context of other information presented to them by the witnesses.

Investigators may also use fire dynamics and various resources within the relevant scientific and engineering literature relating to, for example, how materials identified as being present within the scene will burn. This is so as to understand the specific context of the fire under investigation.

The investigators may also undertake experiments and tests to determine the composition and the combustion properties of materials within the fire scene, and in some cases small or large-scale reconstructions are carefully planned and undertaken so as to generate scientifically valid and correctly measured test data which can then be analysed alongside the data already collected.

All of this relates to the data collection and analysis part of the scientific investigation. At all points, it is important that the examination is undertaken following a scientific process so that there is confidence in the data that is derived.

The information from witnesses and fire patterns at the scene, the knowledge of fire dynamics and the

electrical systems, combined with the results of examinations in the laboratory, are all used to test various hypotheses relating to what might have occurred in the event.

This hypothesis testing should be unbiased and should be undertaken on the basis of the facts that are derived from the investigation. As this process develops, further tests and data may be required in order to answer further questions that arise as the hypotheses are themselves tested.

A consensus can be derived through dialogue between fire investigators in light of the systematic and scientific examination of materials recovered from the fire. However, it may be that insufficient information is available to determine either the area of origin or the cause of a fire conclusively.

By reviewing witness statements and other evidence, including fire patterns and other physical evidence, including, if appropriate, the relocation of items back into their original positions at the fire scene, it may be possible to identify the area of origin of the fire. The success of such an identification will be very dependent upon what physical evidence survives the fire, and on the quality and systematic nature of the investigation that has been carried out.

Determining the specific cause of a fire can be more challenging and will more often than not require in-depth laboratory testing, including possibly destructive testing of items recovered from the fire scene, and testing, occasionally, of exemplar products and equipment to determine whether specific fire caused scenarios are possible.

In determining the cause of a fire, the specific conditions required for combustion that I've outlined must be met and should be supported by the physical evidence recovered from the scene. These conditions are:

(1) A source of localised heat is present for sufficient duration and in the environment of combustible materials such that pyrolysis can occur.

(2) That the evolved pyrolysis products can mix with sufficient oxygen to initiate either smouldering, combustion or flaming combustion given an appropriate ignition source.

(3) That the initial fire can grow and can develop.

It is quite possible, given the destructive nature of a fire, that the area of origin and specific cause of the fire may not be determined.

In the final part of my presentation, I will provide detail of my review of the information provided to me in

relation to the fire investigation that was carried out to determine the origin and the cause of the fire at Grenfell Tower on 14 June 2017.

This is my review of the fire scene investigation which was carried out by others who were on the ground at the fire scene in the immediate aftermath of the fire and on subsequent occasions.

The review of the circumstances leading up to the fire and the timelines and activities of those involved are based exclusively upon information provided to me so far as the expert to the Grenfell Tower public inquiry.

As the proceedings of Phase 1 of the inquiry unfold and the witnesses will tell their stories, some of this information may be updated and new information may come to light. This will provide me with the opportunity to further evaluate the findings of my review and to update my provisional report in due course.

I have used a selection of the videos and photographs I was provided with to illustrate this part of the presentation and, indeed, to illustrate my provisional Phase 1 report.

I intend to cover in this part of my presentation the information relating to the circumstances of the discovery of the fire and the information relating to the actions of the first responders, and in particular

the first firefighters who attended the fire in flat 16 on the fourth floor of Grenfell Tower.

The information provided to me allows a provisional timeline of the early event of the fire to be established. The information also establishes, as far as is possible at this stage, the early intervention activities of the firefighters.

The activities of the fire scene investigators who attended Grenfell Tower also form part of this information-gathering phase. Once this information has been gathered, it can be used to test a series of hypotheses relating to the determination of the area of origin of the fire and the cause of the fire. At the end of this process, a series of provisional conclusions have been reached.

I intend to start with the information-gathering part of my work, which has come from witness statements, from photographs and the notes of the investigators, as well as the reports and videos that have been provided to me.

I will begin this part of the presentation with some orientation to the scene and to flat 16, and then work through a sequence of events from discovery, the firefighter attendance and the fire scene investigation.

During this first section, I will be showing some

photographs of the outside and of the inside of Grenfell Tower. These photographs include pictures of the interior of flat 16 taken very shortly after the fire. I will also be playing part of the initial 999 call to the fire and rescue service, and I will be playing some video footage taken by the first firefighters who entered flat 16, as well as external video footage from outside of Grenfell Tower taken on the night of the fire.

This is the east face of Grenfell Tower. Flat 16 is on the fourth floor of the tower and is illustrated by the red box both on the photograph and in the plan.

This is the north face of Grenfell Tower, where flat 16 again is illustrated in red.

This is a close-up image of the east face of Grenfell Tower, indicating flat 16. The kitchen window of flat 16 is indicated by the red arrow.

Flat 16 was a two-bedroom apartment with a living room and a galley-style kitchen. The available evidence suggests that three people lived in the flat. Mr Kebede slept on a mattress in the living room of the flat, Ms Kinfu occupied bedroom number 1 and Ms Afeworki occupied bedroom number 2.

The kitchen was next to the living room and directly connected to it via a sliding door, which was shut on

the night of the fire. The living room was also connected to the hallway via another door, and immediately opposite this door was the main door into the kitchen.

The existing evidence suggests that in the early hours of 14 June 2017, Mr Kebede had been sleeping on a mattress in the living room of his flat, number 16, in Grenfell Tower. The other two occupants of flat 16, Ms Kinfu and Ms Afeworki, were also asleep in their respective bedrooms.

Mr Kebede was woken up by the sound of his smoke alarm which, as stated in interview with the Metropolitan Police Service, he believed to be the smoke alarm that was in the kitchen of his flat.

Mr Kebede got out of bed and went out of his living room using the door into the hallway. He opened the door into the kitchen from the hallway and he looked inside for a few seconds.

In his most recent statement, I note that Mr Kebede states that when he looked into the kitchen, he saw light-coloured smoke which seemed to be coming from behind the tall fridge freezer located in the southeast part of the kitchen. The smoke was observed as being about two-thirds the height of the fridge freezer.

The existing evidence suggests that Mr Kebede went

back into the living room to get his mobile phone and he dialled 999. He woke both of the other occupants of the flat by banging on their bedroom doors and by telling them that there was a fire in the flat.

He ran out of his flat and made efforts to wake his neighbours in the other flats on the fourth floor. He did this by banging on their front doors and by shouting that there was a fire.

Mr Kebede then returned to his flat to grab a pair of trousers and stated that he switched off the electricity supply to the flat at the fuse box as he exited the flat for the second and last time.

This is important information in terms of the fire investigation because it means that any physical evidence that relates to the interaction of the electrical system of flat 16 and the fire must have occurred at the very early stages of the fire and prior to when the electricity was switched off.

I'm going to play the first part of the call that Mr Kebede made to the London Fire Brigade in a few moments.

At 00.54.29 on 14 June 2017, a call was received at the London Fire Brigade's Stratford fallback control. The time of the call was recorded by the London Fire Brigade and this was the first call received relating to

the incident.

This call was made by Mr Kebede and within which he provided valuable early evidence in relation to the fire. Within the call he indicated to the controller that there was a fire at Grenfell Tower, that the fire was in flat 16, on the fourth floor of the tower, and that the fire was associated with a fridge, which was mentioned by Mr Kebede during the call.

I'm now going to play the call.

(999 call was played)

During that call, Mr Kebede mentions twice that the fire was by the fridge side.

I am only going to focus on the initial deployment of resources to Grenfell Tower by London Fire Brigade on receipt of Mr Kebede's phone call. This is because these early actions provide information which directly addresses my terms of reference in relation to the origin and cause determination of the fire.

Four fire engines were deployed by London Fire Brigade to Grenfell Tower in response to the initial 999 call.

Two fire engines, with resource codes G271 and G272, were deployed from North Kensington. They were mobilised at 00.55.14 and they arrived at Grenfell Tower at 00.59.28, and 00.59.24 respectively.

One fire engine, with resource code G331, was deployed from Kensington. It was mobilised at 00.55.14 and arrived at Grenfell Tower at 1.08.33 am.

One fire engine, with resource code G362, was deployed from Hammersmith. It was mobilised at 00.59.12 and arrived at Grenfell Tower at 1.08.27.

Next, I'm going to show a provisional timeline of the initial London Fire Brigade response as far as it can be determined from the existing evidence. This is the initial 999 call made at 00.54.29.

G271 and G272 were deployed from North Kensington and arrived at almost the same time, approximately 5 minutes after the initial call.

G331 was deployed from Kensington at the same time as G271 and 272 and arrived at Grenfell Tower approximately 14 minutes after the initial 999 call.

G362 was deployed from Hammersmith approximately 4.5 minutes after the initial call and its time of arrival at Grenfell Tower almost coincided with the arrival of G331.

On arrival at Grenfell Tower, the firefighters undertook various tasks and activities in preparation to enter the building and to tackle the fire. Two firefighters from G271 were tasked as the initial team to enter flat 16 on the fourth floor of the tower.

These were Crew Manager Batterbee and Firefighter Brown.

These two firefighters carried with them a thermal imaging camera, which can be used to visualise the interior of rooms where a fire is in progress and to indicate areas of increased temperature within those rooms and compartments when it is used in this way.

The timer on the thermal imaging camera used by Crew Manager Batterbee and Firefighter Brown was incorrect. Analysis by the Metropolitan Police Service suggests that an additional 56 minutes and 42 seconds needed to be added to the time on the camera.

The timings, therefore, of the video footage I have used have been made on the basis that the Metropolitan Police Service's analysis is correct.

I will show the video footage of the thermal imaging camera next. This footage is extracted from sections of the thermal imaging camera footage taken by Crew Manager Batterbee and Firefighter Brown. It shows their progression through the flat and also shows footage externally taken outside of Grenfell Tower.

This external footage, where it was available, shows the development of the fire at the same time as the firefighters were inside the flat, so that a comparison of the external fire development of the fire which was occurring at the same time that the firefighters were

making their way through the flat can be made.

The video footage is shown on a split screen, with the thermal imaging camera footage appearing on the left and the videos from mobile phone footage appearing on the right in order to aid visualisation. The footage is going to play at approximately half speed so that we can follow the activities.

The timings in the footage have been corrected based on the suggested correction provided by the Metropolitan Police Service, and that corrected time runs at the bottom of the video clip.

I am going to show this video footage twice. The first time I will show it all of the way through without commentary. The second time I will show it again all the way through, but this time I will provide some commentary as to the activities of the firefighters from the information available to me so that we can understand what it is that we're seeing.

The video runs for approximately 4 minutes. I am going to show that video footage now.

(Video played)

I'm now going to run that video again and this time I'll talk through some of the items that we're seeing on the video to contextualise. So I'm going to be talking as the video is playing.

At about 1.07, the firefighters enter the flat. Here you see the first firefighter going through the door. The door was closed when they arrived.

Now you see the firefighters moving around the entrance hallway as they start to make an entrance into the first bedroom.

Externally, the fire can be seen through the kitchen window.

The firefighters are now entering the first bedroom, and the thermal imaging camera is reflecting some of the items that are present within that room.

The firefighters are now progressing down the hallway of the flat, and here in the image from the thermal imaging camera you'll see the bottom of the hallway, with the living room door to the left and the kitchen door to the right.

Externally, you can see the level of the fire development.

Here is where the firefighters enter the kitchen for the first time. The yellow glow that you see is the fire that is down at the window end of the kitchen.

The firefighters attempt to put water on the fire and you can see there where the hose reel is spraying water on the fire.

They close the door, and then they open the door

again to see that the fire is still present.

At this point the firefighters are spending some time discussing what tactics they can use in order to tackle the fire that is within the kitchen.

At approximately 1.20, the firefighters enter the kitchen, go right into the kitchen, and they extinguish the fire that was in and around the fridge freezer directly at that point.

The final portion of the video that you are seeing shows the kitchen once the firefighters have extinguished the fire that was in the kitchen. Some of the items that you can see are recognisable, such as kitchen cupboards, and over to the left-hand side the washing machine, the countertops of the kitchen.

So, again, that's the washing machine and there's the bin besides the washing machine. There's an item on the floor that is hotter than the items around it, which is presumably some fire debris.

The camera now swings round and looks out of the window of the flat, and you can see aspects of the cladding that are coming down outside of the window.

That's the cooker. The fridge freezer can be seen with the top door missing and the bottom door open. That's the toaster, a knife set, some of the materials that were left on the draining rack beside the sink.

These images from a fire investigation point of view are very valuable, and they are valuable because they provide factual evidence about the condition and the position of items within the kitchen immediately after the fire was extinguished.

I'm going to highlight again some of these key findings within that perspective of the fire scene investigation.

When the firefighters arrived at the fourth floor of Grenfell Tower, the door to flat 16 was closed. Firefighter Brown broke down the door of the flat. According to the thermal imaging camera, this occurred at around 1.07.23. Firefighter Brown stated that black smoke billowed out of the flat once the door had been opened.

Crew Manager Batterbee entered flat 16 first with the fire hose and Firefighter Brown followed him behind with the thermal imaging camera.

The firefighters initially searched the bedroom directly opposite the front door of flat 16. This was the bedroom that, according to evidence, Ms Kinfu occupied.

The firefighters then moved through the flat to check the other rooms, including the second bedroom which, according to the evidence, was occupied by

Ms Afeworki, and then they moved to the living room.

They reported no sign of the fire in any of these rooms and they reported no sign of the fire in the hallway.

This diagram suggests the possible route that the firefighters took through the flat based on their notes and statements, and they swapped around their roles during their journey through the flat on a number of occasions.

This image shows clearly the hallway of the flat with the living room door to the left and the kitchen door to the right, and both of these doors were closed. This image was taken at just after 1.12 am.

The evidence available from the occupants of flat 16, as well as the photographs and notes of the fire investigators, allow a diagram of the kitchen to be prepared suggesting the most likely positions of various items within the kitchen at the time that the fire occurred. These include a microwave, the positioning of the sink and beside that, beneath the kitchen counter, a washing machine. Beside this is an electric cooker and, finally, the tall fridge freezer.

There was also an old freezer unit and a small fridge unit reported to be positioned near to the window, with the smaller fridge reportedly placed on top

of the old freezer.

The materials present to the left -- that is the east side -- of the tall fridge freezer were not at this point known. However, recent evidence from Mr Kebede may clarify what these items are and I will review this prior to the preparation of my final report for Phase 1 of the inquiry.

Photographs of the early stages of the fire captured by Mr Kebede on his mobile phone show the fire in the kitchen of flat 16 in its early stages. These photographs were taken at around 1.05.39 and provide evidence that the fire appears to be on the south side of the kitchen, which is the side where the majority of the kitchen appliances were positioned. The firefighters had not entered flat 16 when these photographs were taken.

When Crew Manager Batterbee and Firefighter Brown opened the door to the kitchen at about 1.14 am, they immediately saw the fire to the top-left corner of the room as they looked in through the kitchen door. This was in the end of the kitchen where the window was, and approximate positions of the tall fridge freezer and the washing machine have been illustrated in the photograph. The firefighters sprayed the fire with water and closed the door.

They re-opened the door about 15 seconds later and saw that the fire was still burning. They again tried to extinguish the fire from the doorway but without success. The fire was still burning after they opened the door for a third time at about 1.15.

The firefighters finally entered the kitchen at approximately 1.20 and extinguished the fire that was within the kitchen at that point.

This sequence of photographs or still images taken from a mobile phone video and were taken from outside of Grenfell Tower showing the fire developing and growing.

The first embers can be seen falling from the kitchen window of the flat, flat 16, at about 1.08, approximately. This is approximately 1 minute after the firefighters had entered the flat.

The fire begins to extend out of the kitchen of flat 16 by approximately 1.09.30. This is around 5 minutes before the firefighters entered the kitchen for the first time, which is at 1.14 am.

It is now possible to add some further information to the timeline of the early activities relating to the fire.

At 1.07.23, the firefighters entered flat 16, Grenfell Tower, having arrived on site around 8 minutes earlier. This was approximately 13 minutes after

Mr Kebede's initial phone call to the London Fire Brigade.

By 1.09, the fire was emerging from the kitchen of flat 16. This was approximately 15 minutes after Mr Kebede's initial phone call to the London Fire Brigade.

The firefighters opened the kitchen door of flat 16 for the first time at approximately 1.14 am, and this was about 5 minutes after the fire had emerged from the building.

The firefighters extinguished the fire in the kitchen of flat 16, Grenfell Tower, at about 1.20 am, which was approximately 25 minutes after the first call to London Fire Brigade and approximately 11 minutes after the fire had exited the building.

I am now going to turn to the fire scene investigation which was carried out in flat 16 within Grenfell Tower, which occurred over a number of days and which involved a number of different investigators and organisations.

This table that you're looking at summarises the dates of the various investigations which were undertaken and the items recovered from flat 16 during those investigations.

In total, there were three periods of fire

investigation activities undertaken within flat 16 which resulted in the collection of items for further investigation. The first of these occurred during 14 and 15 June 2017. The second was between the period of 11 and 14 July 2017. Finally, there were some visits to flat 16 in November 2017.

What you're seeing on the second column of the table that you're looking at are the various items that were recovered by the fire investigators from the scene and then removed to the laboratory for further investigation.

The initial fire scene investigation was carried out by London Fire Brigade fire investigators on 14 June 2017, and they were joined by fire investigators from Bureau Veritas and Key Forensic Services on 15 June 2017 in order to complete the initial fire scene investigation of flat 16.

The first fire investigators all arrived between 1.58 and 2.23 on 14 June, so in the morning time. They began their work by interviewing the firefighters who initially entered flat 16 and extinguished the fire within the kitchen of the flat.

At around 9 o'clock in the morning of 14 June 2017, the first fire investigators entered flat 16 of Grenfell Tower and began their investigation. At this

point, they began by documenting the scene using contemporaneous notes and recording the scene photographically. Once they had completed these tasks, they left the flat and the building.

The scene was re-entered by the fire investigators later that day. This now included colleagues from Bureau Veritas, who provided the scientific support services to the London Fire Brigade.

The fire investigators continued their scene investigation on 15 June 2017, and at this point some staff from Key Forensic Services were now also present, as well as some of the original fire investigators. Some of the original fire investigators were also no longer involved in the scene investigation.

During these two initial days, the fire scene investigation was focused primarily on the east end of the kitchen, and various items and materials were recovered, packaged and removed to the laboratories of Bureau Veritas for further examination.

Between 11 and 14 July 2017, fire investigators from Bureau Veritas and Key Forensic Services revisited the scene and recovered many of the other electrical items which had been previously in the kitchen. At this time, the dividing wall between the living room and the bedroom, bedroom number 2, had either collapsed or had

been knocked down, and many of the electrical items previously located in the kitchen were now in various parts of the living room or located within the remains of bedroom 2. A wide range of other electrical items were also recovered from elsewhere in the flat and some electrical items that were in the flat were not recovered.

Finally, a further set of items were recovered from flat 16 on various dates in November 2017.

Focusing now on the fire scene investigation which was undertaken on 14 and 15 June 2017.

The fire investigators took various photographs of the scene and documented their activities as they undertook their work.

This photograph is taken looking into the kitchen from the living room and would have been taken as part of the early recording of the fire scene, and before too many of the materials and fire debris had been moved about by the investigators.

The baton at the top of the photograph is associated with the sliding doors and is visible at the ceiling of the interface between the kitchen and the living room.

Starting from the left-hand side of the photograph, closest to me, this is the east side of the room, you can see the window opening, which is visible, and in

front of it the remains of an old freezer and a small fridge, neither of which, according to Mr Kebede, were plugged in at the time of the fire. Mr Kebede also stated that the old fridge freezer no longer worked.

Behind this and along the south wall is a gap between the window and the remains of the tall fridge freezer. When moving along the south wall towards the right-hand side, which is the west side of the room, there are an electrical cooker and the remains of the kitchen counter with the bin and the washing machine underneath that counter. There are some other appliances on the counter, one of which may be the toaster.

Next is the remains of the sink, which has been pulled upwards, then some cupboards and what may be a kettle, and finally a microwave on the counter above the cupboards.

At some point during this initial investigation, the investigators gridded off areas around the cooker and in front of the remains of the old freezer and small fridge and recovered samples from these areas.

The area in front of the cooker looks to have been gridded twice and at different times. The samples that were recovered from these gridded areas were placed in separate sample bags and were removed from flat 16 the

following day on 15 June 2017.

As the investigators undertook the scene investigation, they began to move some of the appliances from the kitchen to elsewhere in the flat, as they focus their activities in and around the remains of the tall fridge freezer and the kitchen window.

It is not certain at this point as to where the other appliances were moved to, but it is thought that most were moved into the living room. Many of these appliances that were originally in the kitchen were recovered from the living room and some from bedroom 2 during the scene investigation that was undertaken in July 2017.

The fire investigators also cleared away the materials to the east side of the tall fridge freezer. That's the side closest to the window. The exact nature of these items and materials has not yet been established; however, the recent evidence from Mr Kebede may clarify what these items are.

What appears to be a large electric cooking pan, later identified as an Ethiopian cooking pan, was removed from this location and was later recovered from the living room of flat 16 during the subsequent visit by the fire investigators in July 2017.

The fire investigators moved the tall fridge

freezer, exposing some of the wiring behind the appliance, which they removed and packaged for further examination.

The fire investigators also recovered parts of the fridge freezer, namely the top door and the compressor unit, as well as some wiring believed to be associated with the fridge freezer, all of which was packaged and removed from the scene on 14 June 2017.

The investigators also exposed the flooring underneath the fridge freezer, which was burnt, and they packaged the flooring material from this area and removed it from the scene on 15 June 2017.

The fire investigators also packaged and removed the remains of a supply flex associated with the fridge freezer and debris from the window area of the kitchen which contained the remains of the extractor fan of the kitchen. These were all removed from the scene on 15 June.

The items that were recovered that I have listed from flat 16 that were recovered by the fire investigators on 14 and 15 June were examined on 19 and 20 June 2017 at the Bureau Veritas laboratories. These were non-destructive visual examinations. This means that the items were removed from their packaging, they were viewed, they were photographed and any damage

described and noted. Measurements of some of the items were taken. Some of the items were examined under magnification and some were examined using X-rays.

Mr Kebede stated that he switched off the electrical supply as he left flat 16, and these images are of the fuse box within flat 16. One of the miniature circuit breakers within the fuse box for the circuit which supplies electricity to the kitchen had operated or tripped. The operation of the miniature circuit breaker must have occurred before the main electricity supply to flat 16 was switched off by Mr Kebede.

This means that if evidence of electrical activity as a result of fire attack or an appliance failure was found within the kitchen of flat 16 in an identified area of origin, then it would have occurred within the very early stages of the development of the fire, when the kitchen circuit and appliances still had electricity available to them.

This means that evidence of electrical activity within an appliance or associated with electrical wiring would provide specific physical evidence linked to the very early stages of the fire's development, and this would greatly assist in narrowing the area of origin of the fire as defined by the electrical system.

Bureau Veritas and Key Forensic Services staff

undertook non-destructive visual examinations of the electrical items recovered from the initial fire scene examination of the kitchen on 14 and 15 June.

As a result of these examinations, they suggested that there was no evidence of electrical activity associated with the items which were recovered from the southeast area of the kitchen of flat 16. However, it is clear that, given the kitchen miniature circuit breaker had operated, electrical activity did indeed occur.

This suggests that further examination of the electrical items which were known to be plugged in, as well as the electrical wiring recovered from the southeast area of the kitchen of flat 16, are needed, and this further work, led by the inquiry's forensic electrical engineering expert, is now continuing.

The investigation of the origin and the cause of a fire is a primary aim of the fire investigation process. The first step is to determine the area of origin, and that normally involves the evaluation of evidence and factual information derived from the following:

Witness information from all relevant parties.

A systematic and careful physical examination of the fire scene and materials and items remaining after the

fire, as well as fire patterns that may exist.

Careful removal of items such as, for example, fire debris samples and/or electrical appliances for subsequent laboratory-based examinations. The removal of such items should be traceable so that where they were taken from, when and by whom is known and their relevance in the context of the scene can be correctly established.

Through such a systematic investigation process, the room of origin can often be identified quickly. This then allows the fire investigators to narrow down the focus and eliminate items that are not relevant to the question of where the fire started.

The determination of the origin of a fire should be based upon the evaluation of a series of hypotheses or propositions which can be tested and evaluated based on available information and physical evidence.

There are three hypotheses to address in relation to the area of origin of the fire in Grenfell Tower on 14 June 2017:

(1) That the fire in Grenfell Tower started in the kitchen of flat 16 as opposed to any other flat in Grenfell Tower.

(2) That the fire started in the southeast end of the kitchen of flat 16 in Grenfell Tower as opposed to

anywhere else in the kitchen.

(3) That the fire started in the southeast corner in or around the area of the tall fridge freezer as opposed to any other appliance or item in the southeast corner of the kitchen of flat 16.

In assessing hypothesis 1, that the fire in Grenfell Tower started in the kitchen of flat 16 as opposed to any other flat in the tower, the following evidence was considered: the witness statements from the occupiers of flat 16 Grenfell Tower and, in particular, the statements of Mr Kebede; the statements of the first attending firefighters; the thermal imaging camera footage from those firefighters; the external footage taken in the early stages of the fire. All of these pieces of evidence, when considered together, place the fire within the kitchen of flat 16.

Taking all of this into consideration, it is my view that it can be concluded with confidence that the fire which occurred in Grenfell Tower on 14 June started in the kitchen of flat 16 on the fourth floor of Grenfell Tower.

In assessing hypothesis 2, that the fire started in the southeast part of the kitchen of flat 16 as opposed to elsewhere within the kitchen, the following was considered: the most recent witness statement from

Mr Kebede states that he saw light smoke coming from behind the tall fridge freezer; the statements of Crew Manager Batterbee and Firefighter Brown positioned the fire in the southeast part of the kitchen; the thermal imaging camera images provide evidence that there was a lack of fire damage to the appliances to the right side or the west side of the tall fridge freezer.

This is the thermal imaging camera footage of the cooker. Here is a toaster and what looks to be a sandwich-maker, and here is the thermal imaging camera image of the items that were beside the sink.

All of these items survived the early stages of the fire, and this means that the damage observed to these items subsequently by the fire investigators during their scene investigation is not related to the area of origin of the fire as they were not involved in the early fire development.

When reviewing this evidence together, it places the area of origin of the fire within the southeast part of the kitchen, which is now highlighted in the drawing.

In the photograph that we saw before, the evidence together places the area of origin of the fire within the southeast part of the kitchen, highlighted now in red on the photograph.

In assessing hypothesis 3, that the fire started in

the southeast corner, in or around the area of the tall fridge freezer, as opposed to any other appliance or item in the southeast corner of the kitchen, the following was considered:

Early external images of the fire indicate that the fire started on the southeast side of the kitchen, rather than the north side where the old fridge freezer and small fridge were reported as being located. This is one of those images.

Both the old fridge freezer and the small fridge were plugged out at the time of the fire. This was confirmed by fire investigators during their examination of the scene and by Bureau Veritas in their examinations.

On the picture closest to me, which is the old freezer, the red circle highlights where the plug to the appliance is. That's clearly hanging down beside the appliance rather than being plugged in.

The witness statement of Mr Kebede and the contemporaneous notes of Firefighter Brown also suggest that the initial fire was not in the old freezer and the small fridge. Mr Kebede stated that he saw light smoke coming from behind the tall fridge freezer and that the old freezer was definitely not working.

Firefighter Brown stated that Crew Manager Batterbee

pointed out that it was a fridge that he had put out. This was towards the right-hand side of the back wall.

On the basis of this evidence, the old freezer and small fridge were not within the area of origin of the fire, although these appliances were clearly involved in the fire at some later point.

This narrows the area of origin further down to the southeast corner of the kitchen. This area includes a portion of the window that contains the extractor fan, and the corner of the room, including the fridge freezer and the materials that were in between the fridge freezer and the window.

The fire investigators recovered several items from this southeast corner of the kitchen during their examination of the scene on 14 and 15 June 2017. These items included:

(1) The tall fridge freezer.

(2) The door of the fridge compartment at the top of the fridge freezer, which had become detached.

(3) The compressor unit of the tall fridge freezer.

(4) Wiring from in or around the base of the tall fridge freezer.

(5) Electrical wiring from behind the tall fridge freezer.

(6) Parts of the laminate flooring from underneath

the tall fridge freezer.
(7) Debris recovered from the window area.
(8) Debris recovered from the gridded areas that I previously described.
Exactly what materials were present in the area between the window and the tall fridge freezer is a point that continues to be investigated, although the large hot plate also described as the electric cooking device was noted and is visible in the photograph.
This item was later recovered on 11 July 2017 from the living room of flat 16. The item was examined in the laboratory and no evidence was found to suggest that it had been plugged in at the time of the fire or that it had a causative role.
The fire investigators from Bureau Veritas and Key Forensic Services state that they carried out a visual examination of the extractor fan recovered from the debris on the windowsill of the kitchen window of flat 16, and that they found no evidence of electrical activity within this device.
The photographic evidence of the early stages of the fire also appears to indicate that the fire was not positioned in the extractor fan panel in the early developmental stages.
Based on this evidence, it is more likely than not

that the extractor fan was not involved in the initial stages of the fire.
The tall fridge freezer, which you're seeing in these images -- the image closest to me shows the left-hand side of the fridge freezer, the image in the middle shows the right-hand side of the fridge freezer and the image to the right of the screen shows the front of the tall fridge freezer with the top door put back in its original position.
The tall fridge freezer has been exposed to fire damage from the bottom to the top, which resulted in a fire pattern and corrosion running the height of the appliance. There is a greater degree of corrosion in evidence towards the rear of the appliance to the front. This is shown in the first fire pattern which I've illustrated here. This pattern is approximately mirrored on both sides of the appliance.
Each side of the tall fridge freezer also reveals a second fire pattern which runs across the sides and the front of the appliance, which is pattern B.
There was a fire pattern observed on the door of the top compartment of the tall fridge freezer, and this may suggest that the unknown materials in the corner and to the left or the east side of the appliance may also have become involved in the fire at the early stages of its

development.
Equally, the fire pattern observed on the door of the fridge freezer may have arisen as a result of ventilation effects from the nearby window.
This is the laminate flooring from underneath the tall fridge freezer. The laminate flooring from underneath the tall fridge freezer was also examined and it revealed a burn pattern within this area that was not present on the laminate flooring on either side of where the fridge freezer was positioned.
This burn pattern -- this is it here -- provides physical evidence to suggest that the area of the laminate flooring directly beneath the tall fridge freezer was exposed to a heat source or direct flame to a greater extent than the laminate on either side of the tall fridge freezer.
The skirting board illustrated here in this area also appears to be burnt away and there is also melting illustrated here to the socket and the conduit to the side that the fridge freezer was positioned on.
This photograph was taken during my visit to Grenfell Tower in October 2017, and this is a photograph of flat 16, looking into the kitchen from the living room. You can see that most, if not all, of the contents of the flat had been removed by this stage.

The fire patterns within this photograph illustrate physical evidence associated with the combustion of the materials within the east side of the living room of flat 16.
There is a large fire pattern extending into the living room, which is here, and this large pattern is most likely associated with the combustion of the old freezer and small fridge, which would have been located here. These items were not involved in the area of origin, but they clearly became involved in the fire at a later point, creating the observed fire pattern.
The other fire patterns suggest that the area of origin of the fire is within the southeast corner of the kitchen, and these fire patterns include:
(1) The lowest area of burning at the skirting board in the southeast part of the kitchen, which corresponds to the position of the tall fridge freezer.
(2) The burn pattern on the laminate flooring corresponding to the position of the tall fridge freezer.
(3) The position of melting on the socket and conduit on the wall next to where the tall fridge freezer was positioned.
This would have been the position of that tall appliance.

The combination of witness statements, the thermal imaging camera footage, the fire patterns on the tall fridge freezer itself and on the laminate flooring beneath the fridge freezer, the skirting board at the back of the fridge freezer and the melting to the sockets adjacent to the fridge freezer suggest that it is more likely than not that the area of origin of the fire was located at the southeast corner of the kitchen, in or around the tall fridge freezer located along the south-facing wall.

This area of origin at this time also extends to the space between the tall fridge freezer and the window, where the exact nature of the materials in this space are still being investigated.

It is my view that further electrical examination of all of the items recovered from this part of the kitchen should be undertaken.

Once the identity of the materials in the space to the east of the tall fridge freezer become known, and the findings of the further electrical examination are available, I will be able to further consider this and to update my provisional report accordingly.

In order to establish the cause of the fire which occurred within flat 16, Grenfell Tower, it is my view that further analysis is required so that the chain of

events needed for a fire to start can be demonstrated. This may include, for example, tests that the sequence required for viable heating, the generation of pyrolysis products and ignition of those products can be demonstrated.

Until that is done and up until this point, only visual, non-destructive examinations of the electrical items removed from flat 16 by the fire investigators have been undertaken and reported. This includes some examinations where some samples have been examined using a microscope and some examinations where some samples have been X-rayed.

However, at this time, no in-depth analysis of the electrical system or combustibility analysis of the tall fridge freezer and its components have been undertaken and reported by any fire investigator involved in the investigation of the origin and the cause of the fire.

As a consequence, it is my opinion that the cause of the fire remains undetermined until further analysis of the tall fridge freezer and other electrical components recovered from the southeast corner of the kitchen of flat 16 can be undertaken.

This work, led by the inquiry's forensic electrical expert, is now continuing.

The initial fire in flat 16 started in the kitchen

in the southeast corner and then spread out of the building. The fire patterns within flat 16, Grenfell Tower, have been interpreted by the fire investigators from Bureau Veritas and Key Forensic Services, who all concluded that after the initial kitchen fire, the fire re-entered flat 16, Grenfell Tower, at a later point in time, and I agree with these conclusions.

At some point, the fire re-entered flat 16 through the window of bedroom 2, causing that room to flash over and subsequent fire to spread out of bedroom 2 and into the hallway, re-entering the kitchen. This caused a second set of fire patterns within the kitchen, primarily to the west end of the kitchen.

The initial fire investigators took a range of photographs during their initial examination of the fire in flat 16. These photographs illustrate the remains of flat 16 and the fire damage within the various rooms of that flat.

Much of the damage to the hallway, looking towards the first bedroom, is due to smoke and to heat. Bedroom 1 does not show much fire damage, although there does appear to be some evidence of burning around the window in bedroom 1.

Bedroom 2 has been fully involved in the fire and

looks to have flashed over. This must have happened after the fire in the kitchen was extinguished as the first firefighters to enter flat 16 checked this room when they entered the flat and found no sign of fire within this room.

The fire damage to the hallway, looking towards the kitchen and living room, shows fire damage at a high level, which must have occurred after the fire re-entered the flat. That is because the thermal imaging footage from the first firefighters did not show any evidence of fire in this hallway.

There is little evidence of direct burning to either the bathroom or the toilet, except at high level. Similarly, the fire damage in the living room, with the exception of the east wall, is relatively superficial. That's what these photographs show.

To my conclusions.

The fire which occurred on 14 June 2017 at Grenfell Tower started in the kitchen of flat 16, which was on the fourth floor.

On the basis of the available evidence, it is more likely than not that the area of origin of the fire was in or around the tall fridge freezer in the southeast part of the kitchen.

At this time, the area between the tall fridge

freezer and the window is also included within this area of origin as the identity of the materials within this space are still being investigated.

The cause of the fire remains undetermined in my view.

The originating fire within flat 16 extended out of the kitchen window of the flat, at some point re-entering through the window of the bedroom next to the living room of flat 16, causing further damage to that flat.

This further damage would not have prevented determination of the area of origin or the cause of the initial fire.

Further electrical examination undertaken by a forensic electrical engineer is required of the materials recovered from flat 16 and this, as I've said, is now underway.

Once the identity of the materials in the space between the tall fridge freezer and the window become known, and the findings of the electrical examination are available, these will be further considered prior to the preparation of my final report for Phase 1 of the public inquiry.

That's all I have to say.

SIR MARTIN MOORE-BICK: Well, thank you very much indeed.

MR KINNIER: Sir, thank you very much. That concludes our business for today.

SIR MARTIN MOORE-BICK: Yes.

Well, thank you all very much. We'll break now and resume tomorrow morning at 10 o'clock, please.

Thank you.

(12.45 pm)

(The hearing adjourned until Wednesday, 20 June 2018 at 10.00 am)

I N D E X