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RRC
Sample
Trainer Pack

NEBOSH
Certificate in Fire Safety
Units FSC1 and FSC2

nebosh

LEARNING PARTNER
GOLD 335

NEBOSH
Certificate in Fire Safety Unit FSC1
Sample Contents

INTRODUCTION

FSC1 SAMPLE - Element 2: Principles of Fire and Explosion

- Lesson plan
- PowerPoint slides
- Study text chapter

SAMPLE - Full list of study text contents for Unit FSC1

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NEBOSH
Certificate in Fire Safety
Unit FSC1
Introduction to the RRC Sample Resource Pack

RRC's Trainer Packs have been designed to include all the resources you need to deliver the NEBOSH Certificate in Fire Safety course. The full pack - of which this is a sample - includes the following resources:

- An electronic copy of the RRC study text (course notes) for the course, supplied for use by the tutor as reference only.
- Daily lesson plans (MS Word) - a suggested breakdown of how the detailed subjects specified in the qualification syllabus will be covered on each day of the course.
- Slides (MS PowerPoint) - full colour slides addressing the subjects specified in, and following the structure of, the qualification syllabus.

Some third-party resources may be suggested in the Lesson Plans, or in the notes to the slides - for example, video footage, further reading, etc. These are not essential and they are not included as part of the licensed Trainer Pack - it is up to the tutor to source the suggested material, should he or she wish to do so.

This ‘Sample Trainer Pack’ contains a selection of pages from the lesson plan, a number of corresponding slides, and the relevant pages from the study text. These pages and slides are representative of the presentation, design and language of the full materials.

For more information, please contact RRC’s customer advisers on 020 8944 3100 or e-mail info@rrc.co.uk

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NEBOSH

Certificate in Fire Safety
Unit FSC1

Sample Classroom Lesson Plan

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NEBOSH Certificate in Fire Safety

FSC1/2 (2021 syllabus) Full Course (4.5-Day Delivery)

This lesson plan is based on the requirements of the FSC1/2 specification and is designed as a guide for tutors in planning their teaching of the course.

The lesson plan is based on 4.5 days of teaching with teaching time of 7 hours per day.

The lesson plan can be easily adapted for other delivery structures, extending the number of days or delivering in shorter sessions.

The duration is based on NEBOSH Guidance and reflects the recommended teaching times. Whilst NEBOSH expects Lesson Plans that comply with the recommended study hours, in practice individual sessions can be shortened and extended depending on the experience, pre-knowledge and English language skills of the learners in a particular group.

Lesson Plan Front Sheet

Tutor:	Course Title and Topic: NEBOSH Certificate in Fire Safety
Venue:	**Date & Time:**
Number of Adult Learners:	**Knowledge/Ability assumed:** This 4.5-day course has been developed to fulfil the requirements of Unit FSC1 and Unit FSC2 of the 2021 syllabus version of the NEBOSH Certificate in Fire Safety. It is likely that some learners will have practical experience of some of the issues covered in the course. Others are likely to have little or no knowledge of the subject matter. In the introduction at the start of the course, the individual learners' present knowledge level should be assessed.
Course Duration: **28 Taught Hours** **20 Private Study Hours**	

Lesson Aims - *the aims of the session are to*:
As per NEBOSH syllabus guide.

Objectives (learning outcomes) - *by the end of the session learners should be able to*:
As per NEBOSH syllabus guide, stated in the study text.

Brief reasoning for the way the lesson has been planned:
The following are guidelines on how the course should be taught. Different tutors obviously have different styles and experiences and these should be taken into account when delivering the course. To keep the learners interested, a variety of different methods should be used and the tutor should not rely solely on slides.

Any constraints:
- The course will require learners to undertake some research.
- They will require at least some access to the internet resources for this purpose.

Equipment/Aids to be used:
- Computer (with internet and sound capability), data projector, flip charts/whiteboard.
- Use of PPT presentations. Though PPT slides exist for most (if not all) subjects covered, they should be used judiciously rather than exclusively.
- Internet access.
- Learners are provided with a printed copy of the study text.
- Tasks are stated on PPT slides (these are, with a few exceptions, short activities to assist learners' learning; tutor's decision on how they should be delivered, e.g. class discussion, learner group work, and learner solo work).
- Questions set for private study may constitute study questions and 'exam skills' questions in study text, RRC mock exam questions or other relevant questions - tutor to make the decision.

FSC1/2 Day 1

7 Taught Hours

TIME	DURATION (MINS)	CONTENT AND TUTOR ACTIVITY	AIDS AND EQUIPMENT	LEARNER ACTIVITY
09:00 - 09:15	**15**	Introduction to the course - overview and aims. Note: Learners to be given a copy of the study text if not already received.	Flip chart	Listening
09:15 - 10:15	**60**	**ELEMENT 1: MANAGING FIRE SAFETY**		
		1.1 Moral and Financial Reasons for Managing Fire Safety ● Moral expectations of good standards of fire safety. ● The financial cost of incidents (insured and uninsured costs), including penalties that could be imposed in the event of a false alarm.	Slides Notes	Listening and participating in discussions
10:15 - 10:30	**15**	**MORNING BREAK**		
10:30 - 11:30	**60**	1.2 The Role of National Governments and International Bodies in Developing Frameworks for the Regulation of Fire Safety ● Employers' responsibilities. ● Workers' responsibilities. ● The role of enforcement agencies and other external agencies including consequences for non-compliance.	Slides Notes	Listening and participating in discussions
11:30 - 12:30	**60**	**ELEMENT 2: PRINCIPLES OF FIRE AND EXPLOSION**		
		2.1 The Principles of the Combustion, Fire Growth and Fire Spread ● The fire triangle. ● Combustion: ○ Chemical reactivity. ○ The conditions for the maintenance of combustion. ○ Examples of combustion products in relation to combustion reaction conditions (complete and incomplete reaction). ○ Exothermic reaction releasing heat energy. ○ Oxidising agents/materials.	Slides Notes	Listening and participating in discussions

12:30 - 13:00	**30**	**LUNCH BREAK**		
13:00 - 15:00	**120**	2.1 The Principles of the Combustion, Fire Growth and Fire Spread - continued ● Methods of heat transfer; conduction, convection, radiation and direct burning and how they contribute to fire and smoke spread through buildings and to neighbouring properties. ● The stages of fire: induction, ignition, fire growth, steady state, and decay. ● Factors that influence fire growth rates and smoke movement. ● Building design (such as cavities, ducts, shafts). ○ Insulated core panels. ○ Construction materials. ○ Internal linings. ○ Ventilation levels. ○ Contents of the premises. ● The conditions required for, mechanisms of, and impacts of flashover and backdraught.	Slides Notes	Listening and participating in discussions
15:00 - 15:15	**15**	**AFTERNOON BREAK**		
15:15 - 16:15	**60**	2.2 The Ignition of Solids, Liquids and Gases ● Meaning and relevance of flash point, fire point and ignition point (kindling point); auto ignition temperature; vapour density; vapour pressure; flammable liquid categories; upper flammable limit; lower flammable limit. ● The conditions required to cause the ignition of combustible solids, flammable liquids and gaseous materials.	Slides Notes	Listening and participating in discussions

16:15 - 17:15	**60**	2.3 Explosion and Explosive Combustion ● Common materials involved in explosions (flammable vapours, gases, dusts). ● The conditions required for, mechanisms of, and impacts of the following types of explosion: ○ Unconfined vapour cloud explosion. ○ Confined vapour cloud explosion. ○ Boiling Liquid Expanding Vapour Explosion (BLEVE). ○ Dust (primary and secondary explosions).	Slides Notes Study questions	Listening and participating in discussions and exercises
17:15 - 17:30	**15**	End of session summary and close.		

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Unit FSC1

Sample PowerPoint Slides

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Fire Triangle

- Fire is a chemical chain reaction in which fuel is reduced by reaction with an oxidiser to produce heat and light.
- To initiate and sustain a fire, three things need to be present at the same time:
  - **Fuel** (e.g. wood, paper, plastic, petrol, etc.).
  - **Oxygen** (usually from the air).
  - **Heat** (e.g. flames, sparks, etc.).

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Fire Triangle

Chemistry of Combustion

- Combustion is a chemical reaction.
- It is a rapid, self-sustaining gas-phase oxidation process which produces heat and light.
- When combustion takes place in solids or liquids, it is the vapours given off which ignite rather than the solid or liquid itself.
- Fuel does not generally spontaneously combust in air, it requires some energy to vaporise sufficient fuel molecules and to initiate the reaction.

Chemistry of Combustion

For the combustion process to proceed and be maintained:

- Energy (heat) is required to vaporise sufficient fuel molecules and to initiate the reaction.
- Once initiated, the heat produced by the reaction itself can supply the heat to sustain further vaporisation and combustion of fuel, so that an external heat source is no longer required.
- For the fire to continue, not only do we need heat, but we also require a constant supply of fuel and oxygen (both of which are consumed by the reaction).

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Combustion Products in Relation to Combustion Reaction Conditions

In **complete combustion:**

Fuel reacts with oxygen and both are completely consumed in the reaction to form new products:

- Methane burns in air:

  $$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

  to produce carbon dioxide and water only.

- Hydrogen burns in air:

  $$2H_2 + O_2 \longrightarrow 2H_2O(g)$$

  to produce water vapour only.

Combustion Products in Relation to Combustion Reaction Conditions

In **incomplete combustion**:

Fuel reacts with limited oxygen so the combustion of the fuel is not complete:

- Methane burns in limited air:

$$4CH_4 + 6O_2 \longrightarrow CO_2 + 2CO_2 + C + 8H_2O$$

to produce carbon dioxide and water, but also carbon monoxide and pure carbon (soot or ash) due to the reduced oxygen supply and the inability for full oxidation to carbon dioxide and water.

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Endothermic and Exothermic Chemical Reactions

- **Exothermic Reactions**
  - Produce heat/energy (although they may require energy to start them off).
- **Endothermic Reactions**
  - Absorb heat/energy from their surroundings. Overall, an input of energy is required for the reaction to take place.
- **Combustion is an exothermic reaction.**

Oxidising Agents/Materials

The higher the concentration of oxygen, the more rapidly burning will proceed. In some workplaces there may be additional sources of oxygen, these include:

- Oxygen cylinders.
- Oxidising agents:
  - Chlorates.
  - Chromates.
  - Hypochlorites.
  - Nitrates.
  - Nitric acid.
  - Peroxides.
  - Peroxyacids.

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The Principles of Combustion, Fire Growth and Fire Spread

IN THIS SECTION...

The combustion process:

- Can be illustrated by the fire triangle, which requires fuel, heat and oxygen to initiate and sustain a fire.
- Is a chemical reaction whereby volatile molecules of fuel react with oxygen, either completely or partially, to generate combustion products.
- Generates heat and is termed 'exothermic'.
- Progresses through the stages of induction, ignition, fire growth, steady state, and decay.

Fire Triangle

To initiate and sustain a fire, three things need to be present at the same time:

- **Fuel** - such as wood, paper, plastic, petrol.
- **Oxygen** - usually from the air, but also from gas cylinders or oxidising agents.
- **Heat** - from ignition sources such as open flames, friction, chemical reactions, sparks from electrical equipment.

If we remove one element from the triangle, fire will not be initiated or sustained:

- If **fuel** is not available or removed, the fire will not start or an existing fire will go out.
- If **oxygen** is absent or removed, the combustion process will not proceed.
- If **heat** from ignition sources is not available, the fire will not start and if heat is removed by cooling, the fire will be extinguished.

The fire triangle

Chemistry of Combustion

DEFINITION

COMBUSTION

A type of chemical reaction - a rapid, self-sustaining gas-phase oxidation process which produces heat and light.

When combustion takes place in solids or liquids, it is the vapours given off that ignite, rather than the solid or liquid itself.

Put simply, volatile (vaporised) molecules of the fuel are combined with oxygen to produce new compounds (combustion products).

For the combustion process to proceed and be maintained:

- Energy (heat) is required to vaporise sufficient fuel molecules and to initiate the reaction. Once initiated, the heat produced by the reaction itself will sustain further vaporisation and combustion of fuel without an external heat source.
- A continued supply of fuel and oxygen is required to replace that consumed by the reaction.

Combustion Products in Relation to Combustion Reaction Conditions

In **complete combustion** - fuel reacts with oxygen and both are completely consumed in the reaction to form new products:

- Methane burns in air:

  $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

  to produce carbon dioxide and water only.

- Hydrogen burns in air:

  $2H_2 + O_2 \rightarrow 2H_2O(g)$

  to produce water vapour only.

In **incomplete combustion** - fuel reacts with limited oxygen so the combustion of the fuel is not complete:

- Methane burns in limited air:

  $4CH_4 + 6O_2 \rightarrow CO_2 + 2CO + C + 8H_2O$

  to produce carbon dioxide and water, but also carbon monoxide and pure carbon (soot or ash) due to the reduced oxygen supply and the inability for full oxidation to carbon dioxide and water.

Exothermic Reaction

The combustion process generates heat as it progresses so this type of chemical reaction is called exothermic, 'exo' (give out) 'thermic' (heat). It is also possible for chemical reactions to require an input of heat to progress and these are called endothermic, 'endo' (take in) 'thermic' (heat) reactions.

TOPIC FOCUS

Chemical reactions can be either exothermic or endothermic:

- **Exothermic reactions**:
  - Release energy in the form of heat, light or sound.
  - Cause an increase in temperature.
  - Can occur spontaneously.
  - May produce heat quickly and can cause explosions.
- **Endothermic reactions**:
  - Absorb energy from the surroundings to proceed.
  - Cause a drop in temperature.
  - Cannot occur spontaneously.

Oxidising Agents/Materials

Combustion requires the presence of oxygen, so the higher the concentration of oxygen in an atmosphere, the more rapidly burning will proceed.

Whilst the most common source of oxygen is obviously the air, in some workplaces there may also be additional sources which can provide a fire with oxygen and so help it burn. These include:

- Oxygen cylinders.
- Oxidising agents, e.g. chlorates, chromates, hypochlorites, nitrates, nitric acid, peroxides and peroxyacids.

Methods of Heat Transfer

A fire will initially spread by **direct burning**, where there is direct contact between the burning material and the new fuel source.

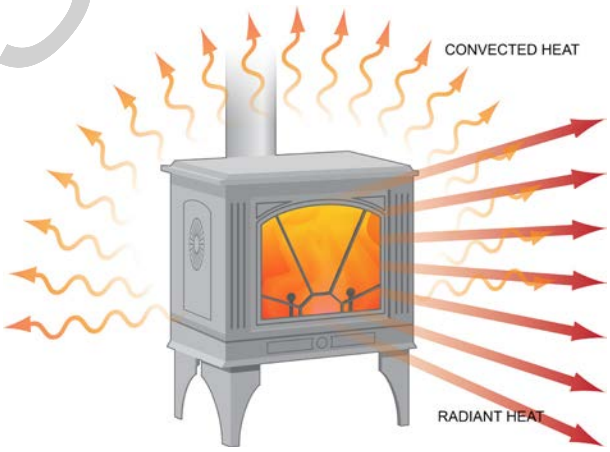
Once established, **conduction** may allow heat transfer through conducting materials to ignite fuel that is remote from the original fire.

Conduction

Convection currents, generated by heated gases expanding, becoming less dense and rising, will transfer heat to surfaces above the fire, such as ceilings and ductwork.

Convection currents

The heated materials in a fire will radiate heat (thermal **radiation** or infrared) which can be absorbed by surfaces near the seat of the fire and cause ignition of nearby fuel.



Radiant heat

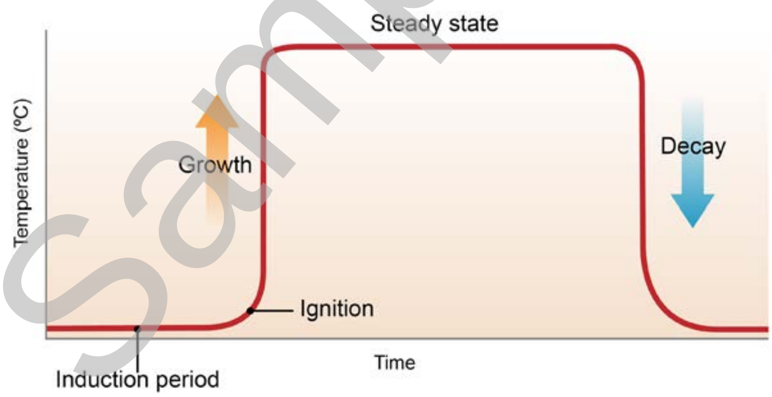
TOPIC FOCUS

The **FOUR** methods by which heat may be transferred during a fire are:

- **Conduction**
  - Molecule-to-molecule transfer of heat through conducting solids such as metal beams or pipes.
  - Heat is transferred to other parts of the building and can ignite combustible or flammable materials.
- **Convection**
  - Hot gases rise and become trapped beneath a ceiling or travel through voids and ducts to other parts of a building.
  - The hot gases ignite combustible or flammable materials.
- **Radiation**
  - Heat is emitted in the form of infrared radiation.
  - Radiant heat can raise the temperature of adjacent materials to above their ignition temperatures or flash points.
- **Direct Burning**
  - Heat comes in direct contact with combustible materials.
  - Direct contact causes ignition.

Stages of Fire

You can see the combustion process illustrated in the following figure:



The stages of combustion

- **Induction** - heat produces sufficient vapour which can mix with air above the fuel and generate a flammable mixture.
- **Ignition** - initiates the reaction and, if it becomes self-sustaining (and no longer requires an external heat source), combustion develops very quickly and there is a dramatic increase in temperature.
- **Fire growth** - the fire may spread through:
  - Direct burning.
  - Typical mechanisms of heat transmission (convection, conduction or radiation).

The rate, scale and pattern of growth depend on a number of factors, such as:

  - Nature, form and amount of fuel.
  - Availability of oxygen (open, ventilated versus sealed containment).
  - Amount of heat produced by the reaction.

- **Steady state** - the temperature stabilises and the combustion process reaches a steady state (the reaction between the fuel and oxygen is balanced until all the fuel is consumed).
- **Decay** - begins when either the fuel or oxygen has been consumed; the fire will then extinguish and gradually cool down.

TOPIC FOCUS

The three basic stages of the combustion process are:

INDUCTION

- Early stages, evidence of combustion starting.
- May be slow process, smouldering.

FIRE GROWTH

- Rapid development of fire as burning materials act as ignition.
- Level of burning and growth depend on levels of oxygen and fuel present.
- Large volumes of smoke and heat generated and possibly spontaneous combustion.
- Growth rate and temperature will eventually reach a plateau.

DECAY

- Room starved of oxygen and fuel.
- Heat output decreases and fire dies down.

Factors that Influence Fire Growth Rates and Smoke Movement

There are also specific factors that influence fire growth rates and smoke movement related to the structure and contents of the particular building:

- **Building design** - where smoke generated from a fire may:
  - Escape through gaps in doorways, ceilings and walls.
  - Spread:
    - Through vents, lift shafts, staircases, ducts and ceiling voids.
    - Horizontally by convective currents under the ceiling.
    - Vertically between storeys by convective transfer of hot gases and smoke.
- **Insulated core panels** (containing fire-rated rigid urethane insulation) - in some cases the insulation material used gives off toxic gases when heated and, when the foam insulation degrades, causes a collapse of the panel.
- **Internal linings** - materials on the surfaces of walls and ceilings significantly affect the spread of fire and its rate of growth:
  - Particularly the potential for fire spread on internal linings in escape routes (rapid fire spread could prevent occupants from escaping).
  - Materials used should reduce the potential for the development of fire and smoke from the surfaces of walls and ceilings.

TOPIC FOCUS

Spread of fire and its rate of growth on the surface of walls and ceilings:

- Properties of lining materials that might **increase** the risk of fire spread and its growth:
  - Ignitability.
  - Rate of surface flame spread and heat release.
  - Amount of smoke produced when ignited.
  - Tendency to produce flaming droplets.
- Properties that lining materials should have to limit the spread of fire and maximise the time available for escape:
  - Resistance to ignition.
  - Low rate of surface flame spread and heat release limiting:
    - Spread of fire.
    - Production of smoke.
    - Rate of fire growth.

  Examples of such materials include:
  - Exposed brickwork.
  - Exposed blockwork.
  - Mineral fibre board.
  - Woodwool slabs.
  - Plasterboard and skim.
  - Intumescent linings.
  - Concrete, stone or ceramic tiles.

DEFINITION

INTUMESCENT LINING

A material that expands when heated to form an insulating fire-retardant barrier that protects the underlying surface.

- A building's construction materials have an impact on the potential for, and rate of, fire spread:
  - Concrete:
    - Dehydrates, crumbles and collapses.
    - Surface spalls (the breakdown of surface layers which crumble into small pebble-like pieces in response to high temperatures) at >300°C; this is increased by steel reinforcement.
    - Loses structural integrity on cooling.
  - Steel:
    - Expands.
    - Conducts heat.
    - Loses strength and deforms as temperature increases.
    - Changes properties on cooling.

- Brickwork:
  - Fired clay bricks exhibit better fire resistance.
- Timber:
  - Combustible and will be consumed and generate smoke in fire.
  - Burns in a predictable way and its fire resistance can be improved by increasing thickness, selection of fire-resistant varieties (dense wood is better) and surface treatment.
- Plastics:
  - Thermo-setting plastics do not melt but decompose, generating smoke and fumes.
  - Thermoplastics melt, drip and flow in a fire and generate smoke and fumes.
- Glass:
  - Generally offers little resistance to fire (but some specific fire-resisting laminated glasses can provide fire resistance of up to 90 minutes).
- Thermal insulating materials in concealed areas:
  - Most modern varieties are non-combustible.
  - Some older buildings used combustible materials (e.g. sawdust).
- Lime-based plaster on internal walls:
  - If supported by lathing or expanded metal, has good fire resistance.
- Paints:
  - Most are combustible and will aid surface spread of fire (but there are also flame-retardant paints and paints that bubble up to protect the timber beneath).

- Ventilation levels determine the oxygen supply to a fire in an enclosed space and, if air is not replenished, the fire will decay. The level may be a combination of:
  - Natural ventilation (through doors, windows and other openings).
  - Forced ventilation (through mechanical air-handling systems).
- Contents of the premises might typically include:
  - Paper (wallpaper, books, magazines) - will burn in a fire and aid fire spread.
  - Plastics (wall and ceiling linings (expanded foam types), window frames) - some types are self-extinguishing (e.g. unplasticised PVC) and others smoulder, drip and burn.
  - Fabrics and furnishings (seating, curtains and other textiles) - natural fabrics tend to smoulder, while synthetic fabrics (mainly thermoplastics) shrink, melt and ignite.

The Conditions in which Flashover and Backdraught May Occur

These two important phenomena increase the risk in a fire situation:

- A flashover occurs when all the combustible material in an enclosed area simultaneously ignites due to heat build-up to above its auto ignition temperature (typically around 500°C).
- A backdraught occurs when air is introduced into a fire which is decaying through oxygen starvation, causing a rapid and explosive re-combustion.

TOPIC FOCUS

A flashover may occur when:

- A fire is free burning in a room.
- There is a good supply of oxygen from the large size of the room or from a ventilation source.
- The fire generates a high level of radiated heat which is absorbed by other materials in the room, including unburnt gases.
- Materials and gases reach their spontaneous ignition temperatures and ignite even though they are not in direct contact with the flame.

The effect is that the fire has 'flashed' from one side of the room to the other.

STUDY QUESTIONS

1. What is the fire triangle. Your answer should include a fully labelled sketch or diagram.
2. What are the conditions required for combustion to be maintained.
3. What are the basic stages of combustion?
4. What is an exothermic reaction?
5. Outline the main factors that influence the rate of fire growth.
6. Outline the ways in which fire can spread within buildings.
7. Outline the main differences between fires under free burning conditions and fires in enclosed conditions.

(Suggested Answers are at the end.)

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Unit FSC1

Full List of Study Text Contents

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Unit FSC1: Final Reminders

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Suggested Answers