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REPORT ON PROPOSED CHANGES TO:

EUROPEAN STANDARD EN 3-7
PORTABLE FIRE EXTINGUISHERS – CHARACTERISTICS, PERFORMANCE REQUIREMENTS AND TEST METHODS

Prepared by
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On the instructions of Britannia Fire Limited

09 June 2025

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1 INTRODUCTION

1.1 I am the Managing Director of Michael Jones Chartered Forensic Fire Electrical Ltd and I am a Forensic Scientist with specialisms in fire investigation and electrical matters. I am a Bachelor of Science in Electrical and Electronic Engineering; I hold the Diploma of the Forensic Science Society in Fire Investigation and have passed the Membership Examination Paper of the Institution of Fire Engineers in Fire Investigation. I am a Chartered Engineer with the Engineering Council and registered by Engineers Europe (formerly FEANI) to practice in Europe, which confers upon me the title Eur Ing; I am also a Chartered Forensic Practitioner. I am a Fellow of the Institution of Engineering and Technology, a Member of the Institution of Fire Engineers and a Fellow of the Chartered Society of Forensic Sciences for whom I am currently the President Elect. I have worked as a Forensic Scientist/Engineer for over thirty years. A copy of my curriculum vitae is attached at **Appendix A**.

1.2 I have been instructed in this matter by Britannia Fire Ltd to review potential changes in the drafting of European standard EN 3-7 "*Portable fire extinguishers. Characteristics, performance requirements and test methods*", which has been revised and circulated for public comment. At Part 3 of section 15.2.3, which deals with the markings to be included on the labels of portable fire extinguishers, there is a recommendation that the following statement be included;

Extinguishers that meet the requirements of clause 8.1 are allowed to be marked: "Not recommended but if used on live electrical equipment up to 1000 V keep the nozzle the minimum distance of 1 m"

1.3 Clause 8.1 specifies the dielectric test at Annex C of the standard, which has not been changed from previous versions. The scope of this clause (clause 9.1 in the current version) has been extended from water-based extinguishers to include clean agent extinguishers that use gaseous or liquid media that do not leave any residue after evaporation; however, a further cautionary note has been added stating;

"*NOTE: Passing the dielectric test is not intended to recommend the use on live electrical equipment but to limit the risk to the operator in case of such use.*"

1.4 No research document, investigative account or anecdotal evidence has been provided by those suggesting the changes to show that the dielectric test does not provide a reliable safeguard to the user of the extinguisher. I, personally, have never been asked to investigate any incident of someone receiving an electric shock when using a fire extinguisher that has passed the test in Annex C of EN3-7, nor have I heard any report of such a matter in all the 3,000 or so fires I have investigated, nor at any professional body conferences, working groups or other such events that I have attended. BS 5306 'Fire Extinguishing Installations & Equipment on Premises', states at Clause 15 that the risk of danger to firefighters in using water based media on live electrical equipment raises only a theoretical risk of electric shock and states further, that neither have the Health & Safety Executive in the UK, recorded any such injury.

2 PHILOSOPHY OF USING WATER SPRAY ON ELECTRICAL FIRES

2.1 I am given to understand that there are principally two types of water based portable fire extinguisher; one simply emits a stream of water but the other emits a pressurised spray. It is the second type, that can be demonstrated to pass the necessary test in Annex C of BS EN 3-7, which is the subject of discussion in this report. The second type can include water based foam, for example.

2.2 The relevant test in BS EN 3-7 is set out in Annex C of that standard, and requires that the extinguisher be operated at a distance of 1 m from a metal plate charged with electricity to a voltage of 35,000 V (35 kV). The electricity supply is connected to earth and during the test, measurements are made between earth and the handle and nozzle of the extinguisher for any leakage current. Clause 9.2 in the main body of BS EN 3-7 states that the leakage current should be no more than 0.5 milliamps (mA) at any time during the complete discharge of the portable fire extinguisher. Prior to the test being undertaken, the source resistance of the high voltage transformer being used in the test is assessed by reducing the output voltage to 10% (ie 3.5 kV) and putting a short-circuit across the output terminals of the transformer. The current through the short-circuit is measured and should not be more than 0.1 mA.

2.3 **Figure 1** sets out the calibration circuit from which it can be derived that the source resistance of the transformer must not be less than 35 megohms (MΩ, where 1MΩ = 1 million Ohms). **Figure 2** demonstrates the circuit during the testing of the extinguisher from which it can be seen that the resistance of the water based media jet must not be less than 665MΩ. In electrical systems, conductivity is the inverse of resistance so in order to pass the test, the conductivity of the water based media stream must not be greater than 1.5 nano-Siemens/metre (nS/m where 1nS = 0.000 000 001S).

2.4 In pure water, two hydrogen atoms are bonded to an oxygen atom by means of covalent bonds to make a molecule of water. The molecule, therefore, has a net electrical charge of zero. By applying a degree of activation energy to a water molecule it can be broken down to form bonds with ionic material and the resulting compounds are capable of forming charged dipoles, which can migrate in the influence of an external voltage to produce a flow of electric current. Principally, the means of making water conductive is to increase its ionic content, for example, salt in sea water. A simple review of information available on the internet suggests that high quality deionised water has a conductivity of approximately 0.5 micro-Siemens per centimetre (μS/cm), drinking water 200 to 800 μS/cm per centimetre and seawater, 50 milli-Siemens per centimetre(mS/cm). By summarising the figures in common units of micro-Siemens/metre (μS/m) we get:

Seawater	500 μS/m
Drinking water	2-8 μS/m
De-ionised water	0.005 μS/m
EN3-7 water based media	0.0015 μS/m

It can be seen that the conductivity of the water based media used in an extinguisher that passes the test of BS EN 3-7 is a third that of high-quality deionised water so is, arguably, three times safer.

2.5 **Figure 3** explains how a spray of de-ionised water based media can achieve such a low level of conductivity. It shows that even if the applied voltage is strong enough to produce such a field between drops of media that the molecule can be polarised, the molecules are separated by the spraying action and, therefore, there can be no migration of charge under the influence of the electric field. In the figure, an example of 240 V AC is given during a time in the wave cycle when one end is positive and the other is negative. In the example, 5 water droplets have been projected from the fire extinguisher nozzle and one is just about to leave, the first drop having reached an exposed, live cable. Ordinarily, there would be a voltage field of 240V/m across all the droplets, but assuming that drops had, somehow, been polarized, then with the drops equally spaced, the strength of the voltage field between each drop is only 48 V over 20 cm, that is, 2.4 V/cm, whereas the electric field strength required to make dry air conductive is 30,000V/cm. Hence, the presence of water droplets cannot distribute the electric field to such a degree as to make intermediate air conductive and instead, conductivity has to be through the water molecules themselves, but because they are in the form of a spray, the molecules are not joined together so there is no continuous stream of water between the two electrodes of the system that could allow the water molecules to become polarised. The use of a spray, therefore, makes even polarized water non-conductive, enabling it to be safe for use on fires involving electrical apparatus.

2.6 **Figure 4** shows the situation where the water based spray is reaching a cable that is surrounded by free radicals in the smoke of a fire. In the example, the free radicals have allowed a breakdown of air between the last and penultimate droplet of media, which means that the voltage of the system now falls across the remaining droplets, increasing the field strength to 3 V per centimetre; this is still a long way from enabling electricity to track back through the whole stream of droplets, which would require in the region of 30kV/cm for the dry gaps between each droplet. Hence, where the media is in close proximity to the fire some of it might become polarised owing to the presence of polarised free radicals in the smoke of the fire, but the remaining stream still maintains a strong resistance to the flow of electric current.

2.7 **Figure 5** is an extract from the American code of practice NFPA 921 "Guide for Fire and Explosion Investigations" and shows how the process of combustion involves the breaking down and reforming of many different species of molecule. For this to happen, the constituent fuel has to be heated so that its internal chemical bonds are broken, and in this way, the molecules will split into free radicals that are charged: at the same time, the oxygen in the air with which the fuel reacts in order to burn, also has to have its covalent bonds broken down by the heat that starts the fire so that the oxygen can form into O^+ and O^- free radicals. The reaction of the oxygen free radicals with the fuel free radicals is the process of combustion and emits light, but as the fire develops, the heat can generate more free radicals than there is time for the combustion reaction to accommodate and this means that above the reaction zone, there will be free radicals that could ionise water droplets to make them conductive.

2.8 Water in liquid form extinguishes a fire by cooling the fuel and preventing it from reacting with the oxygen in the air. Water droplets cool the fire because they turn the water into a form where it has low mass but high surface area and can, therefore, draw heat from the fire to evaporate. The heat of evaporation that they draw, cools the fire rapidly. In doing so, it can be argued that the hot water vapour can react more readily with remaining free radicals and form an ionised mist; however, this will require a degree of time for the reaction to be completed and during that time, the mist will be drawn away with the smoke of the fire in thermal convection currents. In **figure 6** I show that whether the person holding the fire extinguisher is tackling a fire at high level, mid-level or low-level, they are unlikely to have the nozzle of the extinguisher in close proximity either to the point of reaction in the fire or the hot smoke zone. This is particularly true of extinguishers, which passed the EN 3-7, as they are required to be held 1 m away from the fire. It follows that even if there were sufficient time for water droplets at the end of the extinguisher stream be vaporised and react with free radicals in the area, the nozzle of the extinguisher will be away from that zone and will be emitting non charged water droplets. Hence, there will still be an area of non-conductivity in the water spray near the nozzle of the extinguisher.

3 ELECTRIC SHOCK MECHANISM

3.1 The sketch at **figure 7** shows the electric circuit that would be involved if somebody applying a fire extinguisher were to receive an electric shock. The National Grid transformers that supply mains electricity have their star points attached to earth for reasons of operational safety, which means that an electric potential exists between any live conductor and the earth; hence, anyone coming into contact with a live conductor and earth can receive an electric shock. **Appendix B** describes the electricity supply system in more detail; while the nominal single phase electrical supply voltage in the UK is 230V, it used to be 240V and many power stations still generate at that level as it fits within the upper tolerance of the new standard figure. It is often found that mains voltages are still in the region of 240V even though they are nominally considered to be 230V. I have, therefore, used 240V for the basis of the calculations in this report. It can also be seen in reference to Appendix B, that while three phase electrical systems are classed as operating at 400/415 volts, that is the line-to-line value (ie phase to phase) but the voltage to earth from any of those phases is still only 240V, hence, the maximum phase to earth shock voltage available on a three-phase system is only 240V, not 415. This means that from the point of view of somebody potentially receiving an electric shock while using a fire extinguisher in typical commercial and industrial applications, the maximum shock voltage is only 240V, even at the point of supply (ie the meter position).

3.2 In figure 7 I have shown the connection of the grid supply to earth as resistor R_{E1} and the resistance of the grid supply itself as R_S. The resistance of the water jet is R_J, the resistance of the person's body R_B and the resistance between the person and earth, R_{E2}. The international standard IEC 479-1 "*Effects of current on human beings and livestock – Part 1: General aspects*" describes how the effects of electricity on a human can vary according to the frequency of the waveform, the magnitude of the voltage, the duration of the shock and even the geometry of the source of contact. It is, therefore, very difficult to predict exactly how a particular person might respond to exposure to electricity; however, useful summaries are given in figure 14 of the standard and table 4, which I have reproduced here as **figures 8** and **9**. From these it can be seen that a reasonable estimate of the value of the body resistance, R_B, is 2,000Ω. Measurements of R_S, R_{E1} and R_{E2} combined together are often made during the initial testing of an installation and are typically below 10 Ω and, therefore, not significant compared R_B.

3.3 The data in IEC 479-1 suggests that with values of shock current less than 0.5 mA it is unlikely the recipient will feel anything but will feel tingling at higher levels, then pain at around 10 mA. The next stage in the electric shock experience is involuntary muscle actuation as the pulses of the current stimulate the motor control nerve input of the muscles. This will cause all muscles along the current path to activate and in the minor stages could feel like cramp but can soon develop to a position where the user is unable to control their muscles. If the electric shock travels through the arm, then all muscles will be activated and those with the strongest influence will take precedent in which case, the gripping muscles of the hand will clench. If a person is in contact with a live conductor, they will not be able to let go. If the shock current passes through the legs, all the leg muscles are activated and as the kicking muscles are strongest, the legs will straighten out suddenly, giving the impression that the person has been thrown backwards. If the current travels in the area of the heart, it can interfere with the operation of the heart causing it to be erratic (fibrillation) or even stop. As the path of current flow is important in understanding whether the heart might be affected, it is difficult to establish the level of current that might be dangerous in that respect; however, residual current devices are set to operate, typically, at 30mA. This level will not prevent somebody from experiencing the shock, nor experiencing pain but for the short duration of the shock (30ms) it will not be fatal.

3.4 For the person depicted in figure 7 to receive a shock of 30mA would require the resistance of the water jet, R_J, to be approximately 6,000Ω, which is 110,000 times less than the resistance of the water jet that would pass the test of BS EN 3-7.

3.5 It can be seen from the above that it is extremely unlikely that a jet of water which passes the test of BS EN 3-7 can become so conductive that the operator of the fire extinguisher would receive even the slightest sensation of an electric shock, let alone an injurious shock. What is more likely, is that any conductor that is exposed in the fire will form a short-circuit with other conductors, either through charred insulation, smoke or residual firefighting water, and the ensuing short-circuit will cause a fuse, circuit breaker or residual current device to operate and isolate the electricity: Indeed, if the smoke of the fire is so polarised as to ionise a jet of water, the electricity would much sooner pass through the smoke; if the electricity supply fuse does not operate, the ensuing arcing would likely deter someone from approaching the fire with a portable extinguisher.

3.6 In **Appendix C** I have considered the possibility of a person standing in a pool of residual firefighting water receiving an electric shock and from the results, it can be seen that an extremely high level of conductivity would be required in order to produce a shock voltage of 50V between the legs of the user of the extinguisher. The values of conductivity required to either cause a 20A fuse to blow or a 200A fuse to operate are almost a million times greater than the conductivity of sea water. This would require a great deal of absorption by the pool of water of contaminants from the smoke, which would not only have to react fully with the water but do so while the person is still present. Given that the use of handheld fire extinguishers is for first-aid firefighting, it is far more likely that before such a highly conductive pool of water could be formed (if ever), the electricity will have been isolated, the fire extinguisher spent, or the operator moved away from the fire either because it is extinguished, and the area made safe or it has developed beyond first-aid control.

4 DISCUSSION

4.1 Historic and International Application

4.1.1 The idea of using water spray or foam to extinguish fires in electrical equipment is nothing new. The Nuswift engineering company of Elland, Yorkshire, commissioned the English Electric Company research laboratories in Stafford to carry out tests in September 1937 of high pressure water and foam sprays on high voltage electrical apparatus. A short summary is given in the Nuswift leaflet 220 attached at A**ppendix D**. An extinguisher mounted on an insulated stand was directed toward a 12 inch (305 mm) square metal plate, also on an insulator, placed 5 feet (1.524 m) away. The extinguisher was played onto the plate at varying voltages up to 25 KV and a voltmeter, connected to earth, was attached to the nozzle. No voltage reading was obtained. The test was then repeated using the Nuswift foam extinguisher and voltages up to 55 kV. Again, no voltage was recorded on the nozzle.

4.1.2 A second test was undertaken with the extinguisher spray been directed toward a spark gap between two conductors at the potential of 60 kV. Again, no voltage was measured at the nozzle and such was the confidence in the tests, they were repeated by a person holding the extinguisher whilst on wet ground and using their bare hands. No ill effect was felt.

4.1.3 The following year, Nuswift developed a fine spray nozzle for fitting onto standard firefighting hoses so that they could be used to fight oil fires on high voltage switchgear. Test were again carried out by the English Electric Company in May 1938 and detailed in Nuswift leaflet 221 (see **Appendix E**); a high pressure, atomised spray was found to be effective on equipment up to 100 KV although the application distance was increased to 16 feet (4.88 m). This test used ordinary, mains supplied water.

4.1.4 The current British Standard version of EN 3-7, BS EN 3-7, allows for extinguishers that meet the dielectric tests of that standard (Annex C) to be used at voltages of up to 1000 V from a distance of 1 m. The French version of the standard, NF EN 3-7, allows authorised personnel to use an extinguisher, which passes the dielectric test of the standard, up to 20 kV if the nozzle is more than 1 m away from the equipment, and from between 20 kV to 35kV if the nozzle is over 2 m away. An authorised person is an electrician/electrical engineer that meets the requirements of B1 authorisation for low voltage (less than 1000 V) or H1 authorisation for high voltage. Hence, in France a layperson can use an extinguisher that meets the dielectric test of EN 3-7 on low voltage electrical equipment involved in fires so long as they are 1 m away, but authorised electrical personnel can users extinguishers on high voltage equipment. This increase in scope for use of extinguishers that meet this test demonstrates a clear degree of confidence in the efficacy of the tests with regard to electrical safety.

4.2 Summary Views

4.2.1 It must be borne in mind that a shock voltage greater than 240V to earth would only be possible on highly specialised equipment, in which case it is likely that first-aid firefighting would only be carried out by highly trained personnel, if at all. Hence, and from the discussion given above in this report, I do not consider there to be any risk of danger of electric shock to a person using an extinguisher which complies with the requirements of Annex C of BS EN 3-7. I do not, therefore, see any need for the user advice in the current standard to be amended; indeed, I am concerned that the amendment to the standard could give rise to a stronger, alternative risk. The alternative is that first-aid firefighting might not be undertaken because the extinguisher is not considered appropriate and that the fire might grow to a point where it presents a risk of danger to any occupiers of the building, or a risk of significant damage. The whole point of portable fire extinguishers is to have a tool readily available to administer first-aid firefighting. The more versatile that tool, the more chance of it being successful. A water-based extinguisher that passed the requirements of Annex C in BS EN 3-7 would, for example, readily extinguish a fire in a printer without any risk of electric shock to the user, and, thereby, eliminating the risk of the office burning down and personnel being at undue risk/losing employment.

4.2.2 The BS EN 3-7 standard has been adopted from a Europe standard approved by the Comité Européen de Normalisation (CEN) and developed by the French standards body, Association Française de Normalisation (AFNOR). Hence it has international application throughout the European community for other countries that adopt normalised standards; in France it is considered safe for high voltage application by those who would normally be permitted to work on such equipment.

4.2.3 In my view the marking to put on extinguishers that meet the requirements of Annex C of BS EN 3-7 need only say "*Suitable for use on mains voltage electrical equipment from a distance of no less than 1 metre*" as this would deal with all the equipment that might reasonably be expected to be encountered in domestic, commercial and industrial premises in Europe other than specialised equipment. Only authorised personnel would be expected to work on such equipment so would know what to use. As only extinguishers that comply with Annex C of BS EN 3-7 could use this marking, compliance is implicit.

4.2.4 Many fire extinguishers require the user to take specific steps or actions to prevent other risks from occurring prior to or during the discharge of the extinguisher. For example, ordinary water stream fire extinguishers, which do not pass the test in BS EN 3-7, should not be used on electrical fires because they can present the risk of a continuous stream of conductive material forming a bridge between exposed electrical conductors and the user and, therefore, present the risk of electric shock. Carbon Dioxide (CO_2) extinguishers can generate extremely cold temperatures on the nozzle so the user must not hold the nozzle except by means of a good, thermally insulating glove, otherwise they can receive third-degree burns. Fire extinguishers that use halon gas, CO_2 or other oxygen suppressants should not be used in confined spaces otherwise occupiers can become unconscious or suffocate. Powder extinguishers, which use chemicals to neutralise the free radicals in the fire, can cause extreme irritation to the user so should not be used in confined spaces. Users also have to consider whether the fire extinguisher is appropriate for the material involved in the fire so for example, water-based fire extinguishers should not be applied directly to oil-based fires as they can disperse the oil and thereby spread the fire, although water mist extinguishing systems, which use the latent heat of evaporation to cool the fire, can be employed in fixed firefighting equipment installed in for example, kitchens. Hence, there is in any case, a need to train nominated first-aid firefighters on the use of portable extinguishers.

4.2.5 In my view, the suggestion of wording that a measure is not recommended defeats the purpose of a standard and I am not aware of it in any other sphere of operation. The particular concern in this case is that it could prevent someone from taking important action at a critical time and, therefore, increase risk to life.

4.2.6 The use of fire extinguishers that meet the requirements of Annex C is, arguably, more relevant now than before given the increasing use of Direct Current power supplies (e.g. photovoltaic systems) and battery energy storage systems. It is difficult to extinguish an electric arc in a DC system because there is no cyclic zero-crossing point as there is in an Alternating Current waveform. The arc will, therefore, continue until it runs out of material to burn or is interrupted. The stream of extinguishant from a suitable fire extinguisher will disperse the plasma in the arc and, therefore, extinguish the arc.

4.2.7 There is also a potential dichotomy to consider in the wording of the standard regarding non-conductive media. A medium that passes the test of Annex C is, arguably, non-conductive. Consideration should, therefore, be given to what values of conductivity need to be attached to media that are said to be non-conductive. For example, distilled water is used in motor car batteries because at 12V it is considered to be non-conducting.

5 CONCLUSIONS

5.1 In my view, any portable fire extinguisher that passes the test in Annex C of BS EN 3-7 is safe for use on low-voltage, (less than 1000 V AC) mains fed electrical apparatus from a distance of not less than 1m.

5.2 The use of fire extinguishers that meet the requirements of Annex C should be encouraged for application on or near live electrical apparatus less than 1000 V AC. This covers all normal supply and distribution equipment in factories, offices, shops and domestic properties.

5.3 The current trends for increasing the use of DC generation and energy storage make this the appropriate time to encourage the use of fire extinguishers that meet the requirements of Annex C.

5.4 In my view, discouraging the use of fire extinguishers that meet the requirements of Annex C without any documented, validated reason, is irresponsible when considering the risk of fire spread.

6 EXPERT'S DECLARATION

6.1 As a Chartered Engineer I am bound by the Code of Conduct of the Engineering Council and hereby affirm that I have complied with that Code of Conduct in the preparation of this report.

6.2 Amongst other things, the Engineering Council's Code of Conduct requires that;

> Engineering professionals have a duty to acquire and use wisely the understanding, knowledge and skills needed to perform their role. They should:
>
> - always act with care
> - perform services only in areas in which they are currently competent or under competent supervision
> - keep their knowledge and skills up to date
> - assist the development of engineering knowledge and skills in others
> - present and review theory, evidence and interpretation honestly, accurately, objectively and without bias, while respecting reasoned alternative views
> - identify, evaluate, quantify, mitigate and manage risks not knowingly mislead or allow others to be misled

6.3 I understand that should this matter proceed to litigation, my overriding duty will be to assist the Court in matters within my expertise, and that this duty overrides any obligation to those instructing me or by whom my fees are paid. I confirm I have complied with that duty and will continue to do so. I am aware of the requirements set out in Part 35 of the Civil Procedure Rules and the accompanying Practice Direction, the Protocol for the Instructions of Experts to give Evidence in Civil Claims, and the Practice Direction for Pre-action Conduct.

6.4 I confirm that I have made clear which facts and matters referred to in this report are within my own knowledge and which are not. Those that are within my own knowledge I confirm to be true. The opinions I have expressed represent my true and complete professional opinions on the matters to which they refer.

Eur Ing **M Jones** BSc FSSocDip CEng ChFP FIET(MIEE) FCSFS MIFireE MAE

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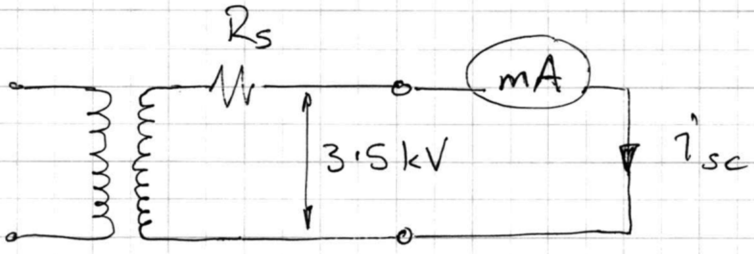
Michael Jones Chartered
MJC FFE
Forensic Fire Electrical

FIGURES

1 - 9

Calibration Circuit



R_s = source resistance of transformer windings

i_{sc} = short circuit current

By Ohm's Law, $V = IR$ hence $i_{sc} R_s = 3.5\,kV$

$$R_s = \frac{3.5\,kV}{i_{sc}}$$

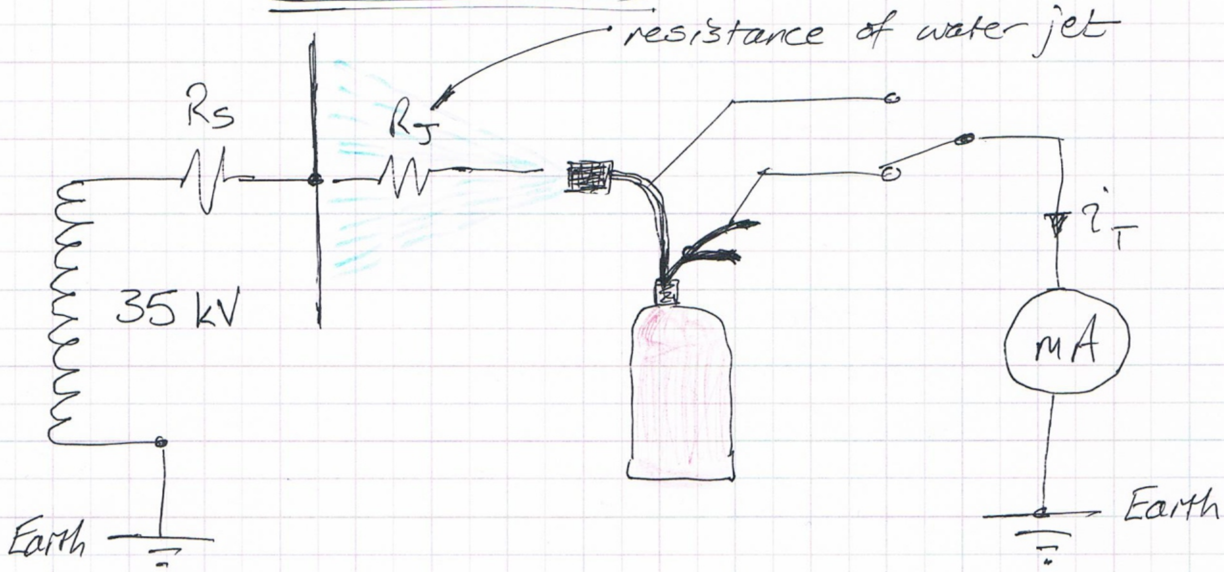
$i_{sc} \nless 0.1\,mA$ $(1 \times 10^{-4} A)$ so

$$R_s \ngtr \frac{3.5 \times 10^3}{1 \times 10^{-4}} = 3.5\ 10^7$$

Hence the source impedance of the test transformer must not be more than 35 MΩ

Figure 1
Calibration circuit for test in Annex C of EN 3-7

Test Circuit BS EN 3-7



To pass the test $i_T \not> 0.5\,mA$ $(5 \times 10^{-4} A)$

Hence $(R_S + R_J) > \dfrac{35 \times 10^4}{5 \times 10^{-4}} = 7 \times 10^8$

$R_S + R_J > 700\ M\Omega$

and $R_S \not< 35\ M\Omega$

$\therefore R_J \not< 665\ M\Omega$.

The resistance of the water jet must not be less than 665 Mega-Ohms.

$\text{Conductivity} = \dfrac{1}{\text{Resistance}}$

Hence conductivity of water spray must not be greater than $1/R_J$

Hence, conductivity $\not> 1.5 \times 10^{-9}$ Siemens/meter

ie $\not> 1.5\,nS/m$

Figure 2
Test circuit of Annex C of EN 3-7

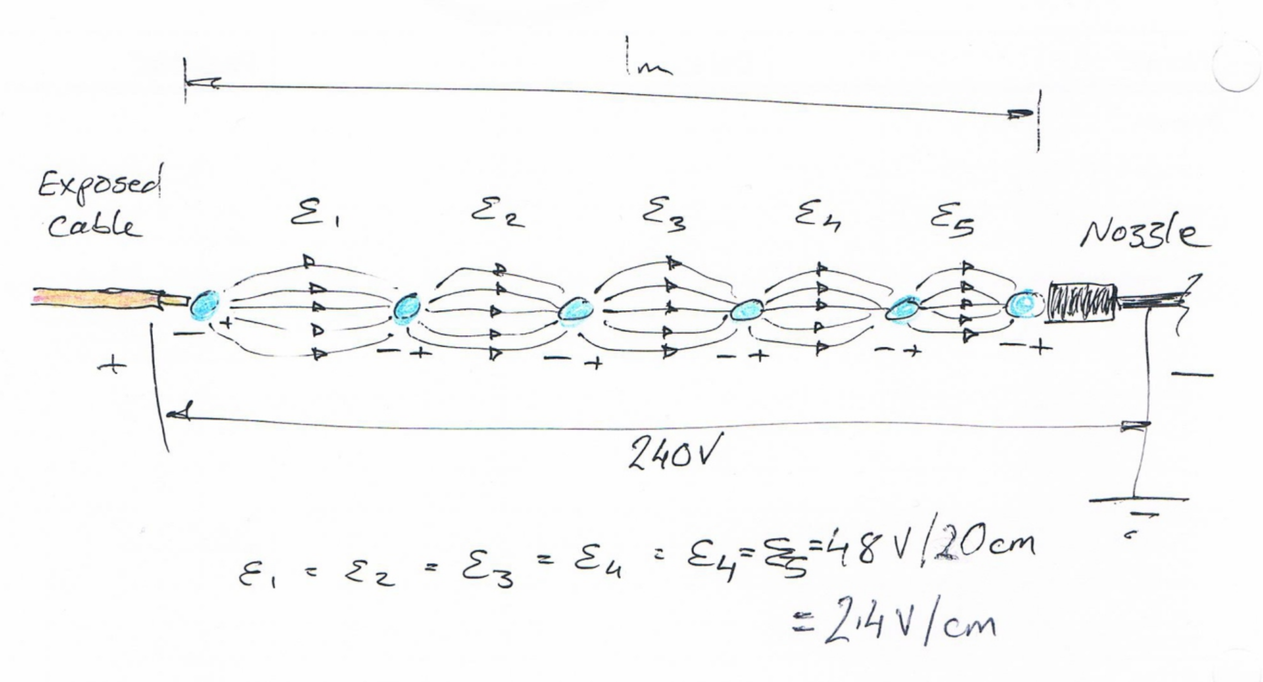


Figure 3
Electric field dispersion in a stream of charged droplets

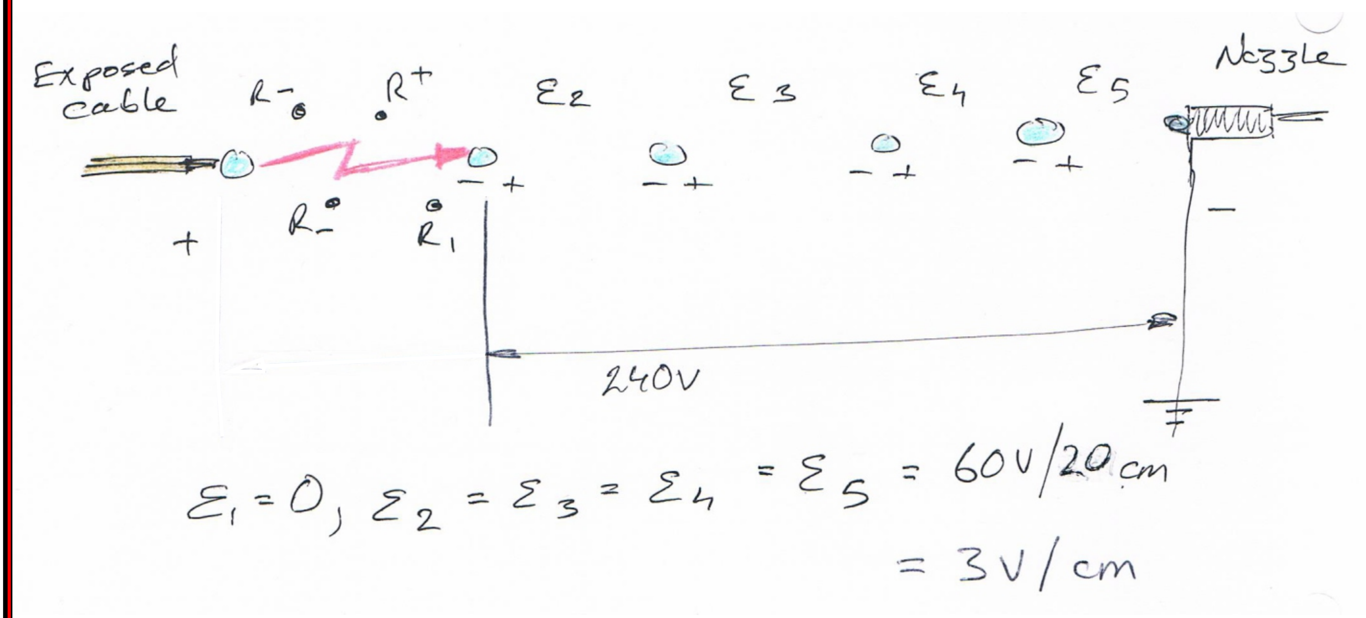


Figure 4
Charged droplet stream entering a charged smoke zone

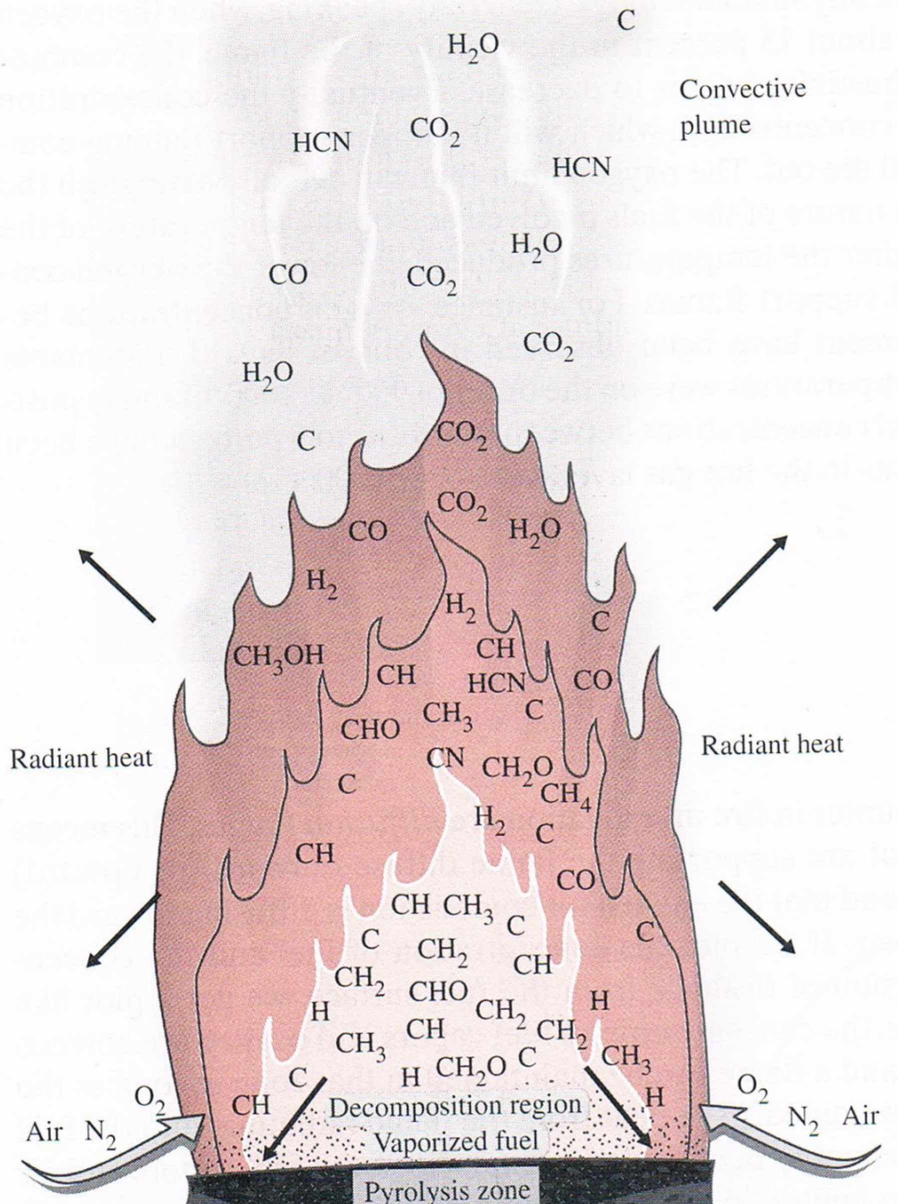
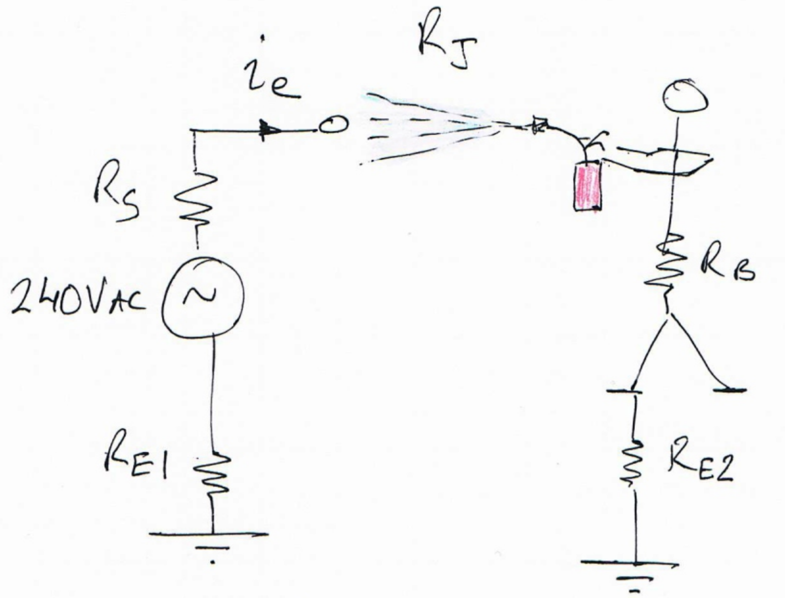


FIGURE 3.1 ◆ Typical flaming combustion of organic fuel showing decomposition region where volatized fuel decomposes to simpler species before combustion and intermediate products are formed.

Figure 5
Extract from NFPA 911 showing species development in a fire

Figure 6
Typical applications of a fire extinguisher



$$i_e = \frac{240}{R_S + R_J + R_B + R_{E2} + R_{E1}}$$

But as $R_J \simeq R_B$ and $R_B \gg R_{E1}, R_S$ and R_{E2}

$$i_e \simeq \frac{240}{R_B + R_J}$$

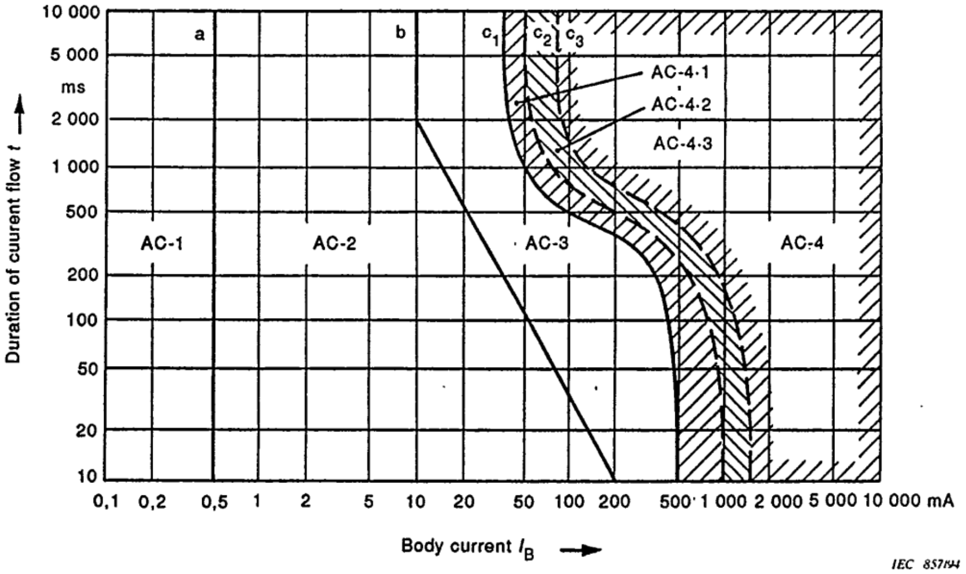
For $i_e < 30mA$ and $R_B \simeq 2{,}000\Omega$

$$R_J > \frac{240}{30 \times 10^{-3}} - 2 \times 10^{-3}$$

$$R_J > 8{,}000 - 2{,}000$$

$$R_J > 6{,}000\ \Omega$$

Figure 7
Circuit diagram when fighting a fire with exposed, live conductors



NOTE – As regards ventricular fibrillation, this figure relates to the effects of current which flows in the path left hand to both feet. For other current paths, see 3.6 and table 5. The threshold values for durations of current flow below 0,2 s apply only to current flowing during the vulnerable period of the cardiac cycle.

Figure 14 – Time/current zones of effects of a.c. currents 15 Hz to 100 Hz
(For explanations, see table 4)

Figure 8
Extract from IEC 479-1

Table 4 – Time/current zones for a.c. 15 Hz to 100 Hz

Zone designation	Zone limits	Physiological effects
AC-1	Up to 0,5 mA line a	Usually no reaction.
AC-2	0,5 mA up to line b *	Usually no harmful physiological effects.
AC-3	Line b up to curve c_1	Usually no organic damage to be expected. Likelihood of cramplike muscular contractions and difficulty in breathing for durations of current-flow longer than 2 s. Reversible disturbances of formation and conduction of impulses in the heart, including atrial fibrillation and transient cardiac arrest without ventricular fibrillation increasing with current magnitude and time.
AC-4	Above curve c_1	Increasing with magnitude and time, dangerous pathophysiological effects such as cardiac arrest, breathing arrest and severe burns may occur in addition to the effects of zone 3.
AC-4.1	c_1-c_2	Probability of ventricular fibrillation increasing up to about 5 %.
AC-4.2	c_2-c_3	Probability of ventricular fibrillation up to about 50 %.
AC-4.3	Beyond curve c_3	Probability of ventricular fibrillation above 50 %.

* For durations of current-flow below 10 ms, the limit for the body current for line b remains constant at a value of 200 mA.

Figure 9
Extract from IEC 479-1

APPENDIX A

AUTHOR'S CURRICULUM VITAE

(4 pages)

Eur Ing Michael Jones

Curriculum Vitae

Qualifications, training, accreditation

Eur Ing	Europäischer Ingenieur. Registered with the Fédération European d'Associations Nationales d'Ingénieur as a practising professional engineer in Europe (a title approved by the Privy Council) (1991)
BSc	Bachelor of Science class 2(i) (1985), Electrical and Electronic Engineering University of Manchester Institute of Science and Technology
FSSocDip	Forensic Science Society Diploma in Fire Investigation (October 2004)
CEng	Registered with the Engineering Council as a practising **Chartered Engineer** in the UK (1991)
ChFP	**Chartered Forensic Practitioner** (Fire Investigation) (2018)
FIET	Fellow of the Institution of Engineering and Technology (January 2022)
MIEE	Corporate Member (**Chartered Electrical Engineer**) of the Institution of Electrical Engineers (1991)
MIFireE	Member of the Institution of Fire Engineers (1997) (passing their examination in fire investigation in September 1996)
FCSFS	Fellow of the Chartered Society of Forensic Sciences (2023)
MAE	Full Practising Member of The Academy of Experts (March 2022)

Past & present positions

Present position: **Managing Director, Michael Jones Chartered Forensic Fire Electrical Ltd**
(November 2019 to present)

Past Positions: **Partner, Geoffrey Hunt & Partners**, Consulting Engineers & Scientists
(2010 to October 2019)

Associate Forensic Engineer, Geoffrey Hunt & Partners (2005 to 2010)

Fire investigator and Forensic Engineer, Capita Insurance Services (formerly Capita McLarens and McLarens Toplis) (1998 to 2005)

- Joined McLarens Toplis to establish a new Fire Investigation and Forensic Engineering service within the company.

Associate Forensic Engineer, R B Hawkins and Associates Ltd (1990 to 1998)

- Investigation of fires, explosions personal injuries and general engineering matters.

Project Engineer, Sira Safety Services (1988 to 1990)

- Engineering consultancy specialising in the testing and certification of electrical apparatus for use in flammable atmospheres. Design and maintenance of explosion protected electrical apparatus. Plant inspections, maintenance audits, Area Classification assessments and product conformity assessments.

Electrical & Instrumentation Design Engineer, British Nuclear Fuels Ltd (1980 to 1988)

- Joined as a sponsored student and worked in the design offices after graduation. Project Engineer in the Electrical and Instrumentation Design Office with secondments to site construction, equipment commissioning, maintenance and quality assurance departments.

Principal professional specialisms

I combine my detailed knowledge of fire investigation with my substantial experience of electrical engineering to provide Expert evidence in such matters as:

- Arson, accidental fires and explosions in a wide range of buildings, vehicles and industrial processes.
- Electrical fires involving white goods, power supply and transmission apparatus (low and high voltage), switchgear and electronic equipment.
- Battery and UPS fires and electric vehicle fires.
- Fire development and spread/breach of compartmentation.
- Policy liability issues regarding warranties, conditions precedent etc.
- Regulatory health and safety issues including safe systems of work, corporate manslaughter and COMAH notifiable events.
- Smouldering, self-heating and spontaneous combustion
- Electric shock and burn injuries and electrocutions.
- Hot work issues.
- Ductwork and catering fires.

Awards, accolades and other professional responsibilities

- First individual in the country to be awarded the qualification status of Chartered Forensic Practitioner (Fire), ChFP in 2018, having been invited to apply by the Society.
- Member of IET Preliminary Investigation Board, reporting to the IET Disciplinary Board, with effect from 01 October 2023
- Member of IFE Working Group 'Charging Points in the Built Environment' November 2021 and ongoing
- An Assessor for the CSFS of the content of proposed CPD events
- Listed by the UK Register of Expert Witnesses since 1999
- Member of CSFS (then FSS) Council 2010 to 2013 and ratified as **President Elect** on 18 October 2024
- Collated the CSFS members' responses to the draft Protocol for Fire Investigation
- Member of the Working Party that reported to the Office of the Deputy Prime Minister, on the National Occupational Standards for Fire Investigators that were published in 2005.
- Committee member of the UK Chapter of the International Association of Arson Investigators (now the UK Association of Fire Investigators) 2009 - 2012

Membership of professional organisations

- Fellow of the Institution of Engineering & Technology (IET), originally joining in 1981
- Registered by the Engineering Council/European Federation of National Engineering Association (FEANI) since 1991
- Fellow of the Chartered Society of Forensic Sciences (CSFS), originally joining in 2002
- Member of the Institution of Fire Engineers (IFE) since 1997
- Fellow of the UK Association of Fire Investigators (UKAFI), originally joining in 2004, and Member of the Central European Association of Fire Investigators (CEAFI) since its inception in 2019
- Member of the International Association of Arson Investigators Inc (IAAI) since 2004
- Full Practising Member of The Academy of Experts since 2022

Published books, papers and editorial roles

- 'Horizontal Fire Spread by Polypropylene, Foam Backed Carpet' - published in Science & Justice, Journal of the Chartered Society of Forensic Sciences (January 2024 - Volume 64 - Issue 2)
- 'The Quarter Power Equation for Resistive Heating Faults' - published in Science & Justice, Journal of the Chartered Society of Forensic Sciences (February 2022 - Volume 62 - Issue 2)
- 'The Need to Regulate Glamping Pods' - published in International Fire Professional, Journal of the Institute of Fire Engineers (February 2022 - Issue 29)
- 'Investigation of Fraudulent Arson Involving a Racing Car' - published in the Proceedings of the 2nd International Symposium of Fire Investigations Science and Technology: National Association of Fire Investigators, Cincinnatti USA (2006) - focus on investigative techniques
- 'Investigation of Fraudulent Arson involving a Racing Car' - published in Science & Justice, Journal of the Forensic Science Society (October 2002 - Volume 44, Issue 4) - focus on inter-agency co-operation

Presentations

I have presented to the Chartered Society of Forensic Sciences, the International Association of Arson Investigators, the UK Association of Fire Investigators and the Central European Association of Fire Investigators on the philosophy and interpretation of fire investigation.

At SIRA Safety Services I designed and presented training courses to the chemical and petro-chemical industries, at site management and practitioner levels, on electrical safety maintenance and the safe use of electrical equipment in potentially hazardous atmospheres. These courses were delivered on a consultancy basis to assist duty holders in understanding and meeting their statutory obligations in this field. I have also provided training on fire investigation to several UK Fire Services, most latterly to Tyne & Wear in September 2023.

Training, qualifications and accreditation as an expert witness

I have worked as a forensic specialist for over 30 years, dealing with over 3,500 cases. I have appeared as an Expert Witness on both sides of Civil and Criminal Courts on more than 50 occasions and have presented at a number of mediations and Coroner's Inquests.

I became a Full Practising Member of The Academy of Experts in March 2022.

I have attended The Academy of Experts (TAE) 'Into Court' course and undertaken a 1:1, half-day Tutorial with Michael Cohen, Chairman Emeritus TAE, both in March 2022. These training interventions cover aspects of acting as an Expert Witness from expert's duties to conduct and procedure in court. I also attended their webinar 'Expert Attendance at Mediations - the Mediator's View' in April 2022. I also attended the Bond Solon Expert Witness Training Conference in November 2023.

I regularly attend teaching and update conferences on all aspects of both forensic fire investigation and electrical engineering. Further, I regularly present on subject expertise matters at conferences and training courses. In October 2023 I presented at the IFE Annual Training Conference on battery issues with Electrical Vehicles, the CE AFI Annual Training Conference in Malta on fire spread in carpets and the philosophy of fire investigation and at the CSFS Annual Training Conference on '3D Scanning for Investigation and Presentation Purposes'.

I last gave live Expert Witness evidence in the matter of R - v – Charlotte Waterson at Manchester Crown Court in July 2024 and before that R (HSE) - v - BMI & ORS at Southwark Crown Court in May 2023.

Summary of Recent CPD Activity

Eur Ing Michael Jones CPD Interventions - Last 3 Years			
Date	**Body**	**Learning & Development Intervention**	**Subject MJ Presentations etc**
08.11.2021 & ongoing	Institution of Fire Engineers	Invitation to join Working group 2 of the special interest group	Charging Points in the Built Environment
04.01.22	Institution of Engineering & Technology	Fellow of the IET status awarded	N/A
26.01.22	Chartered Society of Forensic Sciences	Webinar delivery	Science or Just is? (Part II - Practice)
31.01.22	UK Association of Fire Investigators	Attendance at Annual AGM & January Seminar : Role of the OPSS in identifying unsafe products and the management of product recalls	N/A
23.02.22	Chartered Society of Forensic Sciences	Webinar delivery	Science or Just is? (Part III - Presentation)
Feb 22	Institution of Fire Engineers	Paper published in International Fire Professional, the journal of the Institution of Fire Engineers, February 2022 Issue No 39	The Need to Regulate Glamping Pods
Mar 22	Chartered Society of Forensic Sciences	Paper published in Science & Justice, the journal of the Chartered Society of Forensic Sciences, Volume 62 Issue No 2	The Quarter Power Equation for Resistive Heating Faults
10.03.22	The Academy of Experts	1:1 Half-day Tutorial with Michael Cohen, Chairman Emeritus, TAE - Role of the Expert Witness	N/A
15.03.22	The Academy of Experts	Attendance at 1 day Expert Witness Seminar by TAE - Into Court	N/A
18.03.22	Institution of Engineering & Technology	Webinar - Amendment 2:2022 to BS7671:2018 18th Edition Wiring Regs Launch (17135)	N/A
13.04.22	The Academy of Experts	Webinar - Expert Attendance at Mediations - the Mediator's View	N/A
20.04.22	UK Association of Fire Investigators	Webinar - Electric Vehicles	N/A
24 & 25.05.22	UK Association of Fire Investigators	Attendance at Training Conference - 'Back with a Bang'	N/A
29.06.22	European Association of Fire Investigators	Webinar - King's Cross Fire	N/A
08.06.22	The Academy of Experts	Attendance at Annual TAE Dinner - networking & client entertaining. Pewterers hall, London.	N/A
05.09.22	UK Association of Fire Investigators	Attendance at and delivering presentation to Summer Training Conference	Tolerable Risk
31.10.22	Strathclyde University - Centre for Forensic Science	Invitation to be a guest practitioner to the MSc Forensic Science Cohort	Practitioner Lecture
30 & 31.01.23	UK Association of Fire Investigators	Attendance at and delivering presentation to Autumn Training Conference	CT & Laser Scanning: Analysis & Reconstruction
May 23	Chartered Society of Forensic Sciences	Application for upgrade to become a Fellowship Member of the CSFS	N/A
31.05.23 & 26-27.06.23	Chartered Society of Forensic Sciences	Science & Justice - Introductory webinar and 2-day Workshop attendance at Stoke University.	Successful Writing for Publication
14.06.23	The Academy of Experts	Attendance at Annual TAE Dinner - networking & client entertaining. Pewterers Hall, London.	N/A
Jun 23	Institution of Engineering & Technology	Application submitted for IET Preliminary Investigation Board & Disciplinary Board - Subequent Interview Undertaken 16.6.23	N/A
18.07.23	One Essex Court, Chambers, London	A 1:1 Audience with/presentation to the Rt. Hon Lord Neuberger of Abbotsbury	Philospohy of the Expert Witness
26.07.23	Chartered Society of Forensic Sciences	Fellow of the CSFS status awarded	N/A
06.09.23	Institution of Engineering & Technology	Application for the IET Preliminary Investigation Board & Disciplinary Board accepted & webinar training undertaken; 3 year tenure with effect from 1.10.23.	N/A
17.09.23	Tyne & Wear Fire & Rescue Service, Washington	Course delivery - 1 day	Electricity for Fire Investigators
02 & 03.10.23	European Association of Fire Investigators	Attendance at and delivering 2 x presentations to Annual Training Conference, Malta	1) Science & Law - A Clash of Philosophies 2) Horizontal Fire Spread by Polypropylene Carpet
17.10.23	Institution of Fire Engineers	Presentation to the Annual IFE Conference	Electric Vehicles in the Built Environment
27.10.23	Chartered Society of Forensic Sciences	Attendance at and delivering presentation to Autumn Training Conference Development of 2 x Academic Posters for display	3D Scanning for Investigation and Presentation Purposes
03.11.23	Bond Solon	Attendance at Expert Witness Conference	N/A
29.11.23	Trigon Fire Engineering, Richmond	Invitation to deliver a Lunchtime & Learn Webinar	Fire Investigation & Learnings for Fire Engineers
14.12.23	Institution of Engineering & Technology	Webinar - History of Lego/Engineering the Brick	N/A
18.01.24	The 41 Club (Northwich Branch)	Invitation to present at monthly meeting	Fire Investigation
22.01.24	Chartered Society of Forensic Sciences	Paper published in Science & Justice, the journal of the Chartered Society of Forensic Sciences, Volume 64 Issue No 2	Horizontal Fire Spread by Polypropylene, Foam Backed Carpet
26.01.24	The Academy of Experts	Chairman's Lunch 2024 and Seminar - That was the year that was 2023	N/A
01.02.24	Chartered Society of Forensic Sciences	Appointed Interim President Elect by the Trustees	N/A
16.04.24	The Academy of Experts	Member's Meeting - Understanding Civil Procedure Rules	N/A
23.04.24	Zurich Insurance Company Ltd	Zurich Team Mentoring Programme - MJ presentation	Philosophy of Fire Investigation incl Caase studies
10.05.24	Ministry of Justice	Guest observer at a meeting of the Civil Procedure Rules Committee, MoJ	N/A
12.06.24	The Academy of Experts	Attendance at Annual TAE Dinner - networking & client entertaining. Pewterers Hall, London.	N/A
29.7.24	Chartered Society of Forensic Sciences	CEO Round Table - Defence Expert's Experiences & Views	N/A
18.9.24	Chartered Society of Forensic Sciences	Webinar - The Art of Peer Review	N/A
19.9.24	The Academy of Experts	Webinar - The TAE and Jus Mundi Partnership	N/A
18.10.24	Chartered Society of Forensic Sciences	Attendance at Autumn Conference	N/A
18.10.24	Chartered Society of Forensic Sciences	Ratification as President Elect	N/A
31.01.25	The Academy of Experts	Chairman's Lunch & Seminar - 'That was the year that was 2024'	N/A
03.04.25	Or3D	Or3D Open Day	N/A

APPENDIX B

THREE PHASE ELECTRICITY EXPLAINED

(6 pages)

THREE PHASE ELECTRICITY AND EARTHING

To make most efficient use of generators, three sets of coils are fitted instead of one. **Figure 1** illustrates how electricity is generated from each coil producing a “phase” or “live” supply. As each coil passes through the magnetic field in the generator it produces electricity which will peak in voltage as it passes through the pole of the magnetic field. Hence there are 120˚ of rotation between each phase reaching its peak voltage. There will therefore be a voltage differences between each phase which allows current to flow between them. Where one phase is used by itself to supply a load (e.g. a socket or lighting circuit) then current must return to the generator along a “neutral” conductor.

It is the European standard that the voltage between each pair of phases is 400V. The voltage between any phase and neutral is 230V. By connecting the central point of the generators to earth this ensures that no phase will be at more than 230V above earth under normal conditions.

The three phases can be used by themselves to supply an equally balanced load. Figure 1 shows a three-phase motor connected to the supply. The currents drawn by each coil of the motor will balance out. There will always be one or two phases feeding current into the motor and two or one being used as a return conductor but as each voltage (and current) varies sinusoidally, the resultant load on each phase will be equal and constant.

Where one phase is used by itself to supply a load (e.g. a socket or lighting circuit) then current must return to the generator along a “neutral” conductor otherwise it is not possible for electric current to flow. Hence a neutral connection is made to the central point, or “star point”, of the generator. Single phase electricity is commonly supplied to domestic premises by taking phase and neutral cables from the local distribution transformer and connecting them to each house in a ‘daisy chain’, such that, for example, each third property is connected to the same phase.

If a single-phase load is connected to each phase, then, because they are connected to the neutral bar, the current going through a load connected, say, to the red phase could return via the neutral and via a load connected to the blue phase. If each connected load drew the same amount of peak current, there would be virtually no current flowing through the neutral. If, however, one load draws far more current than the other two, the imbalance of current would return via the neutral.

It is therefore sensible when arranging single phase loads for connection to a three phase supply, to ensure that each phase will supply the same amount of current. This prevents any of the phases or the neutral, being overloaded.

The centre point of the generator is connected to earth (see **Figure 2**) for reasons of transmission system protection. The benefit of this is that the voltages in the system are referenced to earth so it is always known that a single-phase supply will be at 230V (with respect to earth) and two phases at 400V (with respect to each other). The disadvantage is that if a cable is damaged and a person comes into contact with an exposed conductor, current can flow through them to earth and give them an electric shock. It is therefore important to ensure that exposed metalwork is connected together and to a firm earth connection so that in the event of a fault, the current will prefer to flow through the earth conductors rather than the person. Rather than relying on the ground to provide the return path from the consumer's premises to the supply transformer/generator, a cable is run from the star point of the generator/transformer to ensure a good route to 'earth' (ie, the star point) is always available. This can be seen in **Figure 3** where there is a cable from the start point running alongside the power supply cables to the consumer's 'earth' terminal. If the 'earth' conductors are arranged so has to have a very low resistance, the earth fault current will be large and cause rapid operation of protective fuses or circuit breakers thereby ensuring rapid removal of the fault from the system.

From the above it can be seen that when a load is connected to a three-phase supply, the current will circulate through each phase and back through the others. When a load is connected to a single phase, the current will circulate through the phase and back to the point of supply along the neutral. If there is a fault such that a cable comes into contact with earthed apparatus, the current will flow through the phase, through the fortuitous circuit to earth then back through the earth to the generator. This path is known as the 'earth loop' and the resistance (impedance) of the earth loop is an important parameter in the operation of circuit protection. The earth loop impedance is a measure of the resistance to current flow of the whole circuit, including the distribution cables from the electricity sub-station to the premises and back through the earth path. The earth loop is the circuit through which earth fault current will flow; the red dotted line in Figures 2 and 3 illustrate the earth fault loop for the single-phase appliance connected to the blue phase of the electricity supply.

The above descriptions discuss electricity flow from the generator, through the circuit and back to the generator. In practise, the electricity is transmitted over long distances at very high voltages then reduced at a local distribution transformer in a local sub-station. The transformer has three windings arranged in the same way as Figure 2, hence the above discussions about voltage and current still apply.

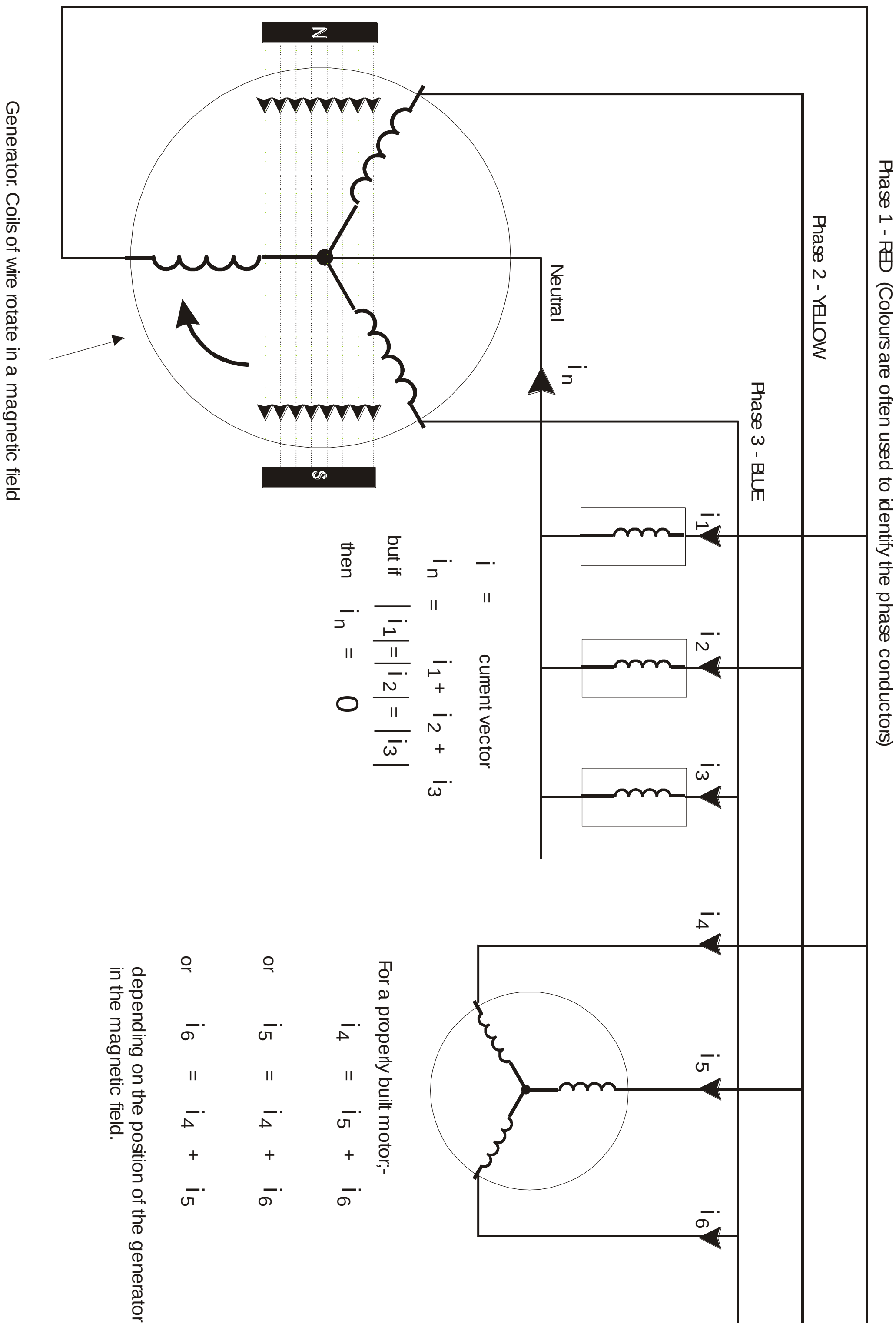


Figure 1.Generation and utilisation of electricity

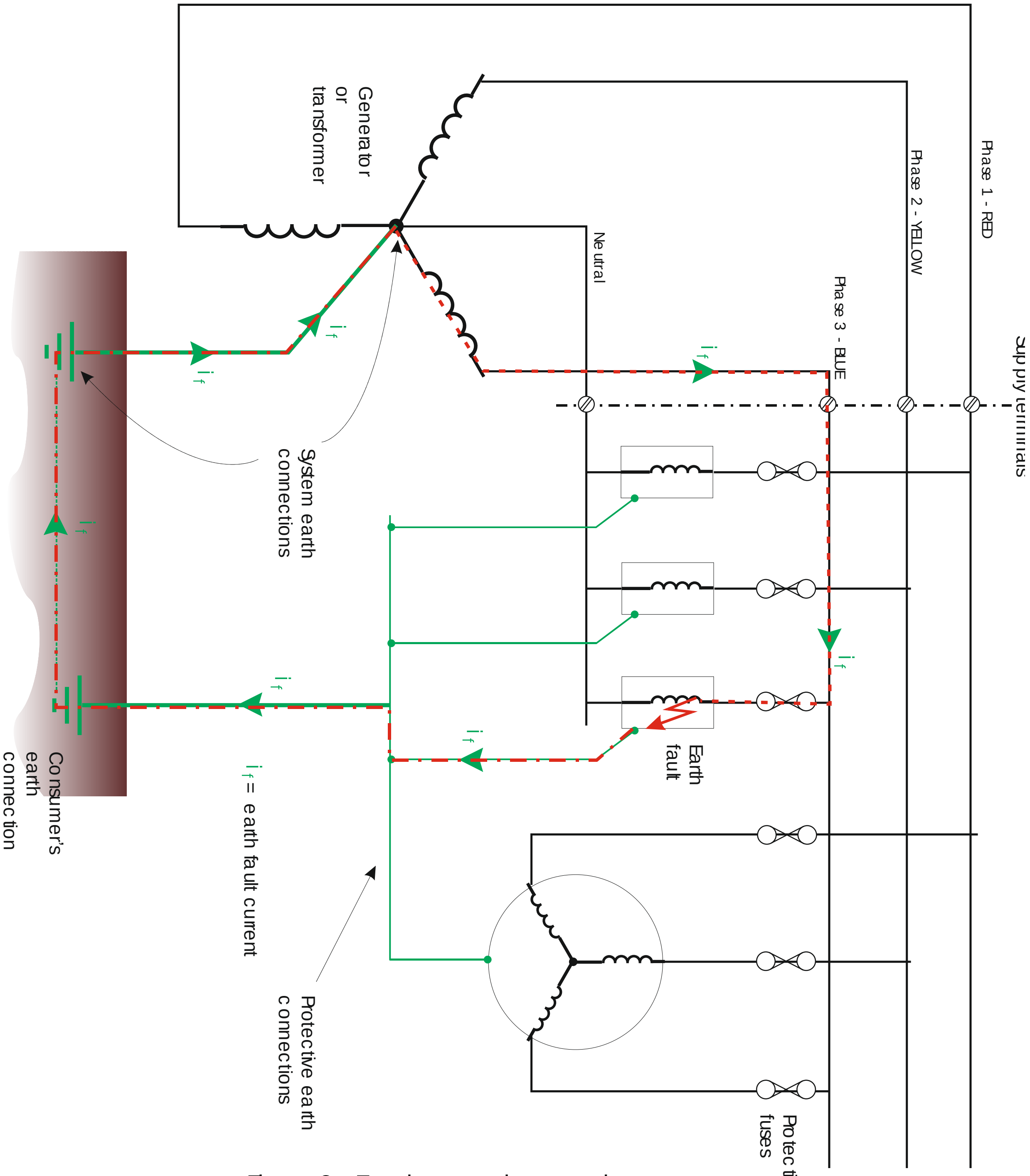


Figure 2. Fortuitous earth protection

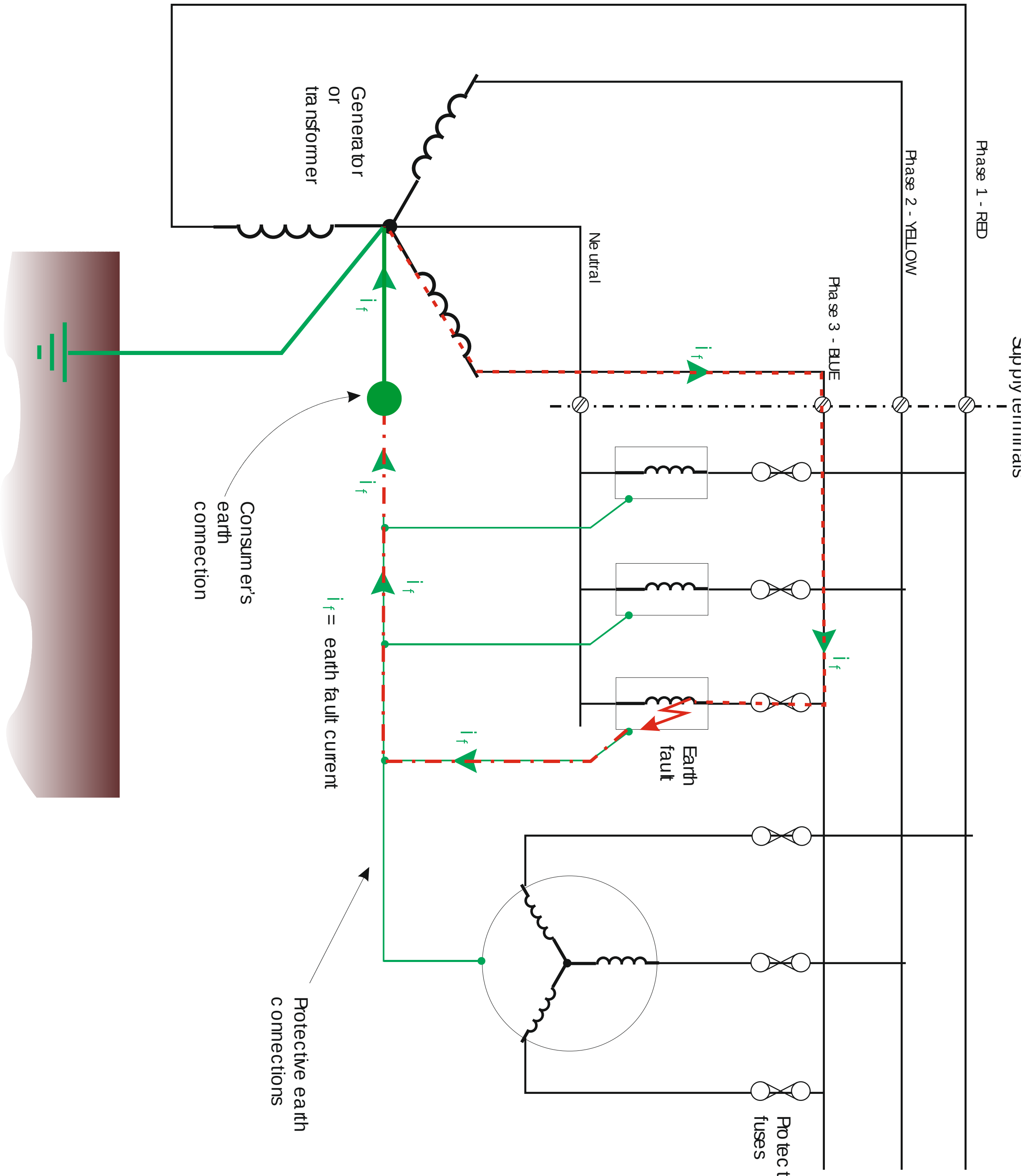


Figure 3. Designed earth protection

APPENDIX C

POOL VOLTAGE EQUATION

(3 pages)

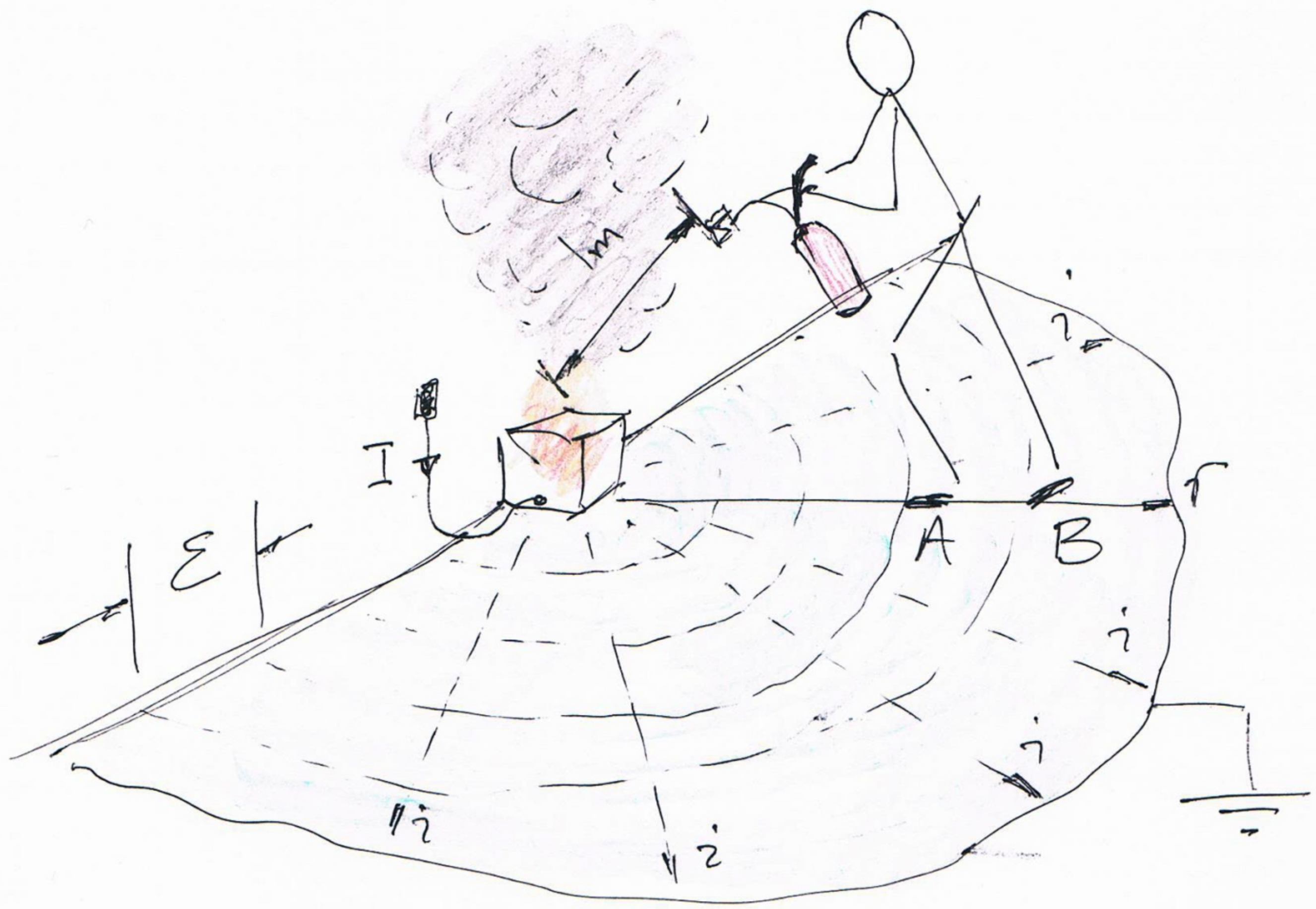


Figure C 1
Electric field and current distribution through a pool of fire-fighting water.

Note of: Water pool shock voltage calculations	MJC-FFE	CASE REF: MJC 50068
Name: MJore	Date: June 2025	Page No: 1/2

Checked By: Date:

Pool voltage equation

$\mathcal{E}$ – Electric field is radial from source (refer fig.)

J – Current density, is sum of currents radiating through pool

Hence $J = \frac{\sum i}{\text{area}} = \frac{I}{\frac{1}{2}\pi r^2} = \frac{2I}{\pi r^2}$

$\mathcal{E} = \rho J$ where ρ is resistivity of pool water

$\therefore \mathcal{E} = \frac{J}{S}$ where S is conductivity of pool water

To find the voltage between feet at positions A,B

$$V = -\int_A^B E\,dr \Rightarrow -\int_A^B \frac{J}{S}\,dr.$$

$$V = -\frac{1}{S}\int_A^B \frac{2I}{\pi r^2}\,dr$$ assuming constant conductivity throughout pool (worst case)

$$\therefore V = -\frac{1}{S}\int_A^B \frac{2I}{\pi r^2}\,dr = -\frac{2}{S\pi}\int_A^B I r^{-2}\,dr.$$

If we assume I is constant because S is constant and consider only the magnitude as the current is alternating:

$$V = \frac{-2I}{S\pi}\Big[-r\Big]_A^B \qquad V = \frac{2I}{S\pi}\Big[r\Big]_A^B$$

Note of: Water pool shock voltage calculations	MJC-FFE	CASE REF: MJC 50068
Name: MJones	Date: June 2025	Page No: 2/2

Checked By: Date:

Pool Voltage Equations

Refer to figure

If we consider that foot A is below the nozzle of the extinguisher then $r_A = 1.0$. Assume foot B is 600mm behind for a strong stance, $r_B = 1.6$

Hence $V = \frac{2I}{S\pi}\left[1.6 - 1\right] = \frac{1.2\,I}{S\pi}$

from which $S = \frac{1.2\,I}{\pi\,V}$

If we assume the fire is in an appliance connected by a 13A plug containing a typical BS 1361 fuse then with a fuse factor of 1.5, the operating current is 19.5 Amps, say 20A.

At the limit of Safety Extra Low voltage, 50V

$S = \frac{1.2 \times 20}{\pi \times 50} = \frac{24}{157} = 0.153$ S/m.

If we assume the fire is in 3φ equipment supplied by a BS 88 fuse with a 1.4 fuse factor then, at 200A rating,

$S = \frac{1.2 \times 200 \times 1.4}{\pi \times 50} = 2.14$ S/m

APPENDIX D

NUSWIFT LEAFLET 220, 1937

(2 pages)

THE ENGLISH ELECTRIC COMPANY LTD., STAFFORD
RESEARCH DEPARTMENT REPORT

Report No. 1051, September 27th, 1937

TESTS (TO DETERMINE ELECTRICAL SAFETY)

carried out on **FIRE EXTINGUISHERS** supplied by The Nuswift ENGINEERING COMPANY LTD.

SEE OTHER SIDE OF THIS LEAFLET for details of TESTS, with references to these diagrammatic illustrations

Fig. 1

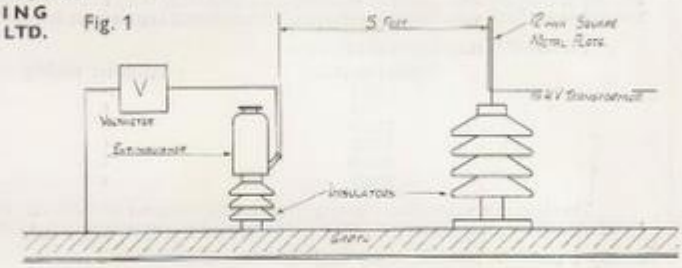
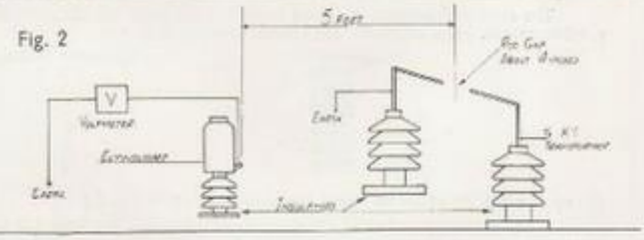


Fig. 2



English Electric Co
Stafford
Research Dept. Report N-1051

Chief Insulation and Research Engineer

C. B. Jameson

These tests have been carried out for The Nuswift Engineering Co. Ltd., and enquiries should therefore be addressed to The Nuswift Engineering Co. Ltd., Protector Works, Elland, Yorks., and NOT to the English Electric Co. Ltd.

P.T.O.

TESTS carried out on FIRE EXTINGUISHERS

SUPPLIED BY THE Nuswift ENGINEERING CO. LTD.

Object.

The object of tests was to determine if the jet from two classes of Extinguisher, i.e.

1. R.S.Q. Water Machine
2. Nuswift Foam Extinguisher

could be directed on high voltage electrical appliances without risk of shock to the operator of the Extinguisher.

NUSWIFT R.S.Q. MACHINE

Tests on Water Machine. (See Fig. 1.)

A metal plate 12" × 12" was placed on an insulated support and the jet of the water machine directed at the plate from a distance of 5 feet, the Extinguisher being insulated from earth. A moving iron voltmeter—100 volts full-scale deflection was connected between the Extinguisher jet and earth.

The following results were obtained :—

Voltage on plate	Voltmeter reading
2500	0
5000	0
10000	0
15000	0
20000	0
25000	0

The above test was repeated using an electrostatic voltmeter with 200 volts full-scale deflection. Identical results were obtained with this voltmeter, there being no deflection up to 25000 volts.

NUSWIFT FOAM EXTINGUISHERS

Group 1 tests on Nuswift Foam Extinguisher. (See Fig. 1.)

The same arrangement was used in conjunction with the electrostatic voltmeter as for the previous test on water machine. The results were as follows :—

Voltage on plate.	Voltmeter reading.
10000	0
20000	0
30000	0
40000	0
50000	0
55000	0

Group 2 tests on Nuswift Foam Extinguisher. (See Fig. 2.)

A rod gap composed of ½" diameter copper rods with flat ends and spaced approximately 4" apart, was mounted on insulated supports, and voltage applied to give flashover. The Extinguisher jet was directed from a distance of 5 feet directly at the gap. The electrostatic voltmeter was connected to the nozzle with the Extinguisher insulated from earth. The following results were obtained :—

Voltage on gap.	Voltmeter reading
60000	0

BOTH

Tests with un-insulated Extinguishers.

As the tests on the R.S.Q. water machine and foam machine all indicated that there was no conduction of electricity through the jet of extinguishing material at the voltage stated, the whole series of tests was repeated with the Extinguishers un-insulated and held in the bare hands by the Nuswift representative, who was standing on wet earth, and no ill effects were felt.

W. Nelson

Research Department

APPENDIX E

NUSWIFT LEAFLET 221, 1938

(2 pages)

THE ENGLISH ELECTRIC COMPANY LTD., STAFFORD

RESEARCH DEPARTMENT REPORT

REPORT No. 1051a, May 5th, 1938

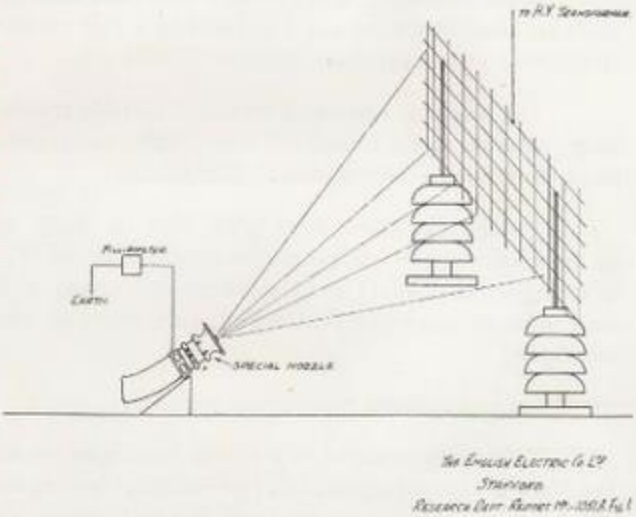
TESTS

carried out on the "**FYREX**" WATER JET

supplied by The

Nuswift ENGINEERING CO., LTD.

SEE OTHER SIDE OF THIS LEAFLET for details of **TESTS,** with reference to this diagrammatic sketch.



Chief Insulation and Research Engineer

These tests have been carried out for the Nuswift Engineering Co. Ltd., and enquiries should therefore be addressed to The Nuswift Engineering Co. Ltd., Protector Works, Elland, Yorks., and NOT to the English Electric Co. Ltd.

P.T.O.

TESTS *carried out on* "FYREX" WATER JET

SUPPLIED BY THE Nuswift **ENGINEERING CO. LTD.**

TO DETERMINE SAFETY OF OPERATOR : NO SHOCK

OBJECT

The object of the tests was to determine if this special atomising jet, when fixed to the branchpipe of the standard type of firemen's hose, working direct from the water mains, could be used on electrical apparatus which was alive at varying voltages.

TESTS

Metal framework approximately four feet square was mounted upon porcelain insulators and connected to a high tension power type transformer with a maximum output of 100,000 volts.

The special nozzle was mounted on suitable trestles sixteen feet away from the metal framework, the nozzle being solidly connected to earth through a milliammeter. (See sketch)

Voltage was raised from 1,000 volts to 98,000 volts while the jet was played on the framework, the stream from the "Fyrex" jet being so arranged that it would be suitable for extinguishing oil fires which are most likely to occur on electrical gear, particularly on transformers and switchgear.

PROOF "POSITIVE" — No milliammeter reading was recorded.

Tests were repeated in a similar manner to the above, but with The Nuswift Engineering Co., Ltd. representative holding the nozzle in his bare hands and standing on wet earth, and no ill effects were felt.

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