A EUROPEAN VIEW OF ARC FLASH HAZARDS AND ELECTRICAL SAFETY

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Abstract - IEEE 1584™ and NFPA 70E® might have been "Made in the U.S.A." but both of these standards have been gaining increased use in arc flash and electrical safety practices found in many other countries around the world. This global use could lead to the conclusion that electrical safety practices may also be the same in each country. Although there are similarities, many distinct differences also exist. This paper provides an overview of electrical safety practices used in countries such as the U.K., Ireland and the European Community compared to those found in the United States.

In addition, the paper will reflect on several other global approaches to arc flash protection and testing practices such as the International Electrotechnical Commission's IEC 61482-1-2 "Box Test" method for PPE testing and the European Arc Guide.

Index Terms - Electricity at Work Regulations, IEC Box Test, European Arc Guide, arc flash, electrical safety

I. INTRODUCTION

The authors published several papers in Europe in 2007 and 2008 that raised the awareness of arc flash within the United Kingdom and Ireland and have worked together on writing arc flash guidance for the greater audience of Duty Holders throughout Europe. In Europe, arc flash requirements are much less prescriptive than in the US and there is also a perception that there is often a greater need for justifying work on or near live conductors.

The authors and UK Health and Safety Executive officials (HSE is the UK version of OSHA) were speakers at a major conference held in London on the subject of arc flash which led to one of the first public discussions of differences (and similarities) in arc flash protection philosophies in the United States, the United Kingdom and Europe.

Much of the law governing the arc flash hazard in Europe comes out of European Directives with specific areas such as management of health and safety, use of work equipment and personal protective equipment directives. Within the framework of these directives, member countries pass their own legislation. Some legislation can be fairly unique such as Great Britain's Corporate Manslaughter Act, which went into effect on April 6, 2008. This clarifies the criminal liabilities of companies including large organizations where serious failures in the management of health and safety result in a fatality.

Arc flash is a global hazard and countries worldwide continue to develop proper safety practices to protect their workers.

II. EUROPE - ELECTRICAL SAFETY

There is no doubt that firm prescriptive guidance for arc flash in Europe is not as advanced as in the United States where the National Fire Protection Association's NFPA 70E Standard for Electrical Safety in the Workplace is in existence. Naturally this does not mean that the problem of arc flash does not exist nor is it unacknowledged, it is more a case of an approach to hazard and risk that is different.

A. European Union

The European Union consists of 27 member countries with over 500 million citizens speaking 23 different official languages and providing for over a quarter of the global economy in terms of GDP. Laws that are passed as Regulations or Directives within the EU are mandatory across all member states and form the starting point for electrical safety compliance.

B. Framework Directive

In 1989, what would be known as the "Framework Directive" number 89/391/EEC (Workplace Health and Safety Directive) [1] was passed which introduced measures to encourage improvements to the safety and health of workers. A cornerstone of this directive is risk assessment which means that there are no prescriptive standards covering electrical safety, especially arc flash, and certainly no link from the hazard directly into arc flash PPE.

Directive 89/391/EEC creates an obligation on behalf of the employer to assess the level of risk involved in the workplace and the effectiveness of the precautions in place. For electrical work, all hazards should be considered, including the arc flash hazard and not purely shock, as is often the case with many European companies. Arc flash risk assessment for workers who operate in proximity to or on energized electrical equipment, cables and overhead lines, is an essential part of electrical safety management. Electrical work has to be carried out with conductors de-energized and isolated wherever possible and there is a very low tolerance for live working in many European countries. This is similar to the requirements for establishing an electrically safe work condition in the U.S.

As a result, many manufacturing plants restrict live working to inspection, diagnostic testing and commissioning purposes. There are however, many tasks that require working either on, or in close proximity to, energized equipment. Even then it should also be acknowledged that the process of de-energization often requires exposure to the hazard through interactions such as switching, racking and testing of equipment.

III. OTHER EU DIRECTIVES

The following is a list of EU directives that have the most impact, in addition to the Framework Directive, on the management of the arc flash hazard.

A. PPE Directive

European Council Directive 89/656/EEC [2] covers the minimum health and safety requirements for the use by workers of personal protective equipment at the workplace.

The PPE Directive sets the minimum requirements for the assessment, selection and correct use of personal protective equipment. Priority must be given to collective safety measures. PPE can only be used where the existing risks cannot be sufficiently limited by technical means or collective protection or work organization procedures. The employer must also provide the appropriate equipment free of charge and ensure that it is in good working order and hygienic condition.

PPE can only be prescribed after the employer has analyzed the risks which cannot be avoided by other means. For arc flash this means an employer must consider other means of achieving safety prior to considering the use of PPE such as the elimination of hazard, engineering controls and safe systems of work. Issues of use, which must be part of the risk assessment process, must include ergonomics, sensory deprivation of user, continuing integrity of PPE and other injury mechanisms, including loss of hearing and sight. In summary, PPE must be used as a last resort.

B. Use of Work Equipment Directive 2009/104/EC

This Use of Work Equipment Directive 2009/104/EC [3] defines the minimum health & safety requirements for the operation of work equipment by employees at work.

The employer is obliged to take every measure to ensure the safety of the work equipment made available to workers. During the selection of the work equipment the employer shall pay attention to the specific working conditions which exist at the workplace, especially in relation to the health & safety of workers. If risks cannot be fully eliminated during the operation of the work equipment, the employer shall take appropriate measures to minimize them. Employers have to provide workers with adequate, comprehensible information, usually in the form of written instructions, not only for the use of the equipment but also foreseeable abnormal situations. Workers shall be made aware of dangers relevant to them. The employer shall ensure that workers receive adequate training, including risks and specific training on specific-risk equipments.

Arc flash risk enhancing situations such the lack of proper equipment maintenance, inadequate equipment design and installation, deficient commissioning and initial inspection and poor worker competence should not happen if working within the "Use of Work Equipment Directive".

C. Provision of Health and Safety Signs at Work.

Council Directive 92/58/EEC [4] defines the minimum requirements for the provision of health and/or safety signs at work and compliments the Framework Directive 89/391/EEC on health and safety at work.

This directive states that safety and/or health signs must be provided where hazards cannot be adequately reduced by techniques for collective protection or by measures, methods or procedures used in the organization of work. In other words, as required by a risk assessment in circumstances where risks to health and safety have not been avoided by other means, for example engineering controls or safe systems of work. Signs must be standardized across Europe in a way in which will reduce the hazards which may arise from linguistic and cultural differences between workers.

Safety signs are to warn of any remaining significant risk or to instruct employees of the measures they must take in relation to these risks. It is very important that employees fully understand the meaning of such safety signs and are aware of the consequences of not following the warning or instruction given by the sign.

It should be noted that arc flash labelling and field marking must conform to Directive 92/58/EEC and in fact labels based on the U.S. ANSI Z535 Standard would not be acceptable in most instances.

IV. UK AND IRELAND

Most legislation in member states is driven by Acts & Regulations backed up by Codes of Practice and voluntary guidance based on national and international standards. It is through this local legislation that the EU Framework Directive is translated.

The cornerstone of this legislation is Risk Assessment and there is a move away from prescriptive measures which may involve a direct link from the arc flash hazard into PPE. In other words, the goal is to eliminate, minimise or mitigate the hazard before considering PPE. A result of this is a much lower tolerance of live working for workers in the industrial sectors and even utility workers will have to justify working on or near energized conductors. For instance, in Ireland and the United Kingdom the regulations covering live working are stated as follows.

A. EAWR Regulation 14

Regulation 14 of the UK Electricity at Work Regulations (EAWR) [5] and 86d of the Irish Safety Health and Welfare at Work (General Application) Regulations [6] requires that three conditions are met for live working to be permitted where danger may arise. It is stressed that if just one of these conditions cannot be met, live working cannot be permitted and dead working is necessary. The conditions are:

- It is unreasonable in all the circumstances for the conductor to be dead; and
- It is reasonable in all the circumstances for the person to be at work on or near that conductor while it is live; and

- Suitable precautions (including, where necessary, the provision of personal protective equipment) have been taken to prevent injury.

This rigorous test of reasonableness even refers to diagnostic testing of live conductors.

Contrast this against the requirements of US legislation expressed in OSHA 1910.333 (a) (1) [7] & NFPA 70E 130.1 [8] and Canadian standard CSA Z462 4.3.1 [9] which states that the employer cannot allow work to proceed "energized" or "live" except when it can be demonstrate that:

- De-energizing introduces additional or increased hazards
- Infeasible due to equipment design or operational limitations

B. UK Corporate Manslaughter Act

The Corporate Manslaughter and Corporate Homicide Act introduces a new offense for prosecuting companies and other organizations where there has been a gross failing throughout the organization in the management of health and safety with fatal consequences. Although not a European Directive and only enforceable in the UK, the penalties for those convicted under the new legislation are extremely severe. The fines have no upper limit and there is also a publicity order which means that the company will have to publicise the details of the conviction. The former damages the company balance sheet but the latter damages the company brand which, in many cases is PRICELESS.

The new offense came into force in 2008 and compliments the existing law where individuals can be prosecuted for gross negligence manslaughter/culpable homicide and for health and safety offenses. The Act does not change this and prosecutions against individuals will continue to be taken where there is sufficient evidence and it is in the public interest to do so. The new offense applies to all companies and other corporate bodies operating in the UK, whether incorporated in the UK or abroad. This means the new legislation also applies to the many US owned companies operating in the UK.

C. Arc Flash Risk Assessment

The arc flash hazard needs to be determined by risk assessment, out of which the decision to work live or dead and the required precautions will be derived. The need for risk assessment is embodied in European Law through Directive 89/391 (EU Workplace Health and Safety Directive) and the associated guidance which identifies electrical work as a "high risk" activity.

The European Agency for Safety and Health at Work defines risk assessment as the process of evaluating risks to worker's safety and health from workplace hazards. It is a systematic examination of all aspects of work that considers:

- what could cause injury or harm;
- whether the hazards could be eliminated; and if not:
- what preventative or protective measures are, or should be, in place to control the risks.

V. EUROPEAN ARC GUIDE

The authors have played a significant role when it comes to influencing the Europeans in their approach to the electric arc hazard. In 2007, they published an article called "Fear of Flashover" which appeared in a major UK electrotechnical magazine. It was argued that UK engineers and managers who are responsible for putting people to work on high power electrical systems can learn a great deal from the US research on arc flash. There are differences in the way in which Europeans approach the subject of electrical safety as described, but an arc flash study will give a rigorous and qualitative approach to determine the hazard, who might be harmed and how, evaluation of risks and work place precautions. After participating as senior or key note speakers at many European events such as arc flash forums, electrical safety seminars and webinars across Europe, it was determined that better guidance regarding arc flash and electrical safety was necessary..

Mr. Frain was the major consultant for the European Arc Guide which was written over a period of three years to address the lack of clear guidance for European Engineers. With the support of a major global company and involvement of Mr. Phillips the project has culminated in a single source of information including charts and calculators. The European Arc-Guide uses IEEE 1584 *Guide for Performing Arc Flash Calculations* for prediction of the hazard severity and then sets out a clear cycle of prevention, protection and publishing the risk assessment.

The European Arc-Guide was developed to take the user through a step by step approach to the management of the arc flash hazard. The following describes the unique 4 P's [10] concept and approach which will always start with a dead working policy as a matter of principle and a range of risk control measures before considering Personal Protective Equipment (PPE) as a last resort to protect individuals should an arc flash occur.

Figure 1. Predict, Prevent, Protect and Publish [10]

The cycle matrix diagram illustrates how the important first step of predict is necessarily followed by prevent, protect and then finally publish.

A. Predict

The severity of the thermal effect of an arc flash is defined by the amount of "incident energy" that a victim, standing at a given distance away from the arc, could receive to the skin surface. The "incident energy" is the value calculated which defines the severity of the arc flash. It can be quantified in units of kilojoules/meter^2 (kJ/m^2), Joule/centimetre^2 (J/cm^2) and calories/centimetre^2 (cal/cm^2). One cal/cm^2 is equal to 4.184 J/cm^2, and is equal to 41.84 kJ/m^2. Units of cal/cm^2 are most commonly used as this is specified for PPE garment labels according to IEC 61482-2 but there is pressure to use the SI unit of kJ/m^2 in Europe.

The calculation methods are taken from the IEEE 1584 Guide for Performing Arc Flash Hazard Calculations 2002 and take into account distance to worker, conductor gap, voltage, prospective fault current and disconnection time. There are accurate calculators to determine prospective fault current; which is always a key element in predicting arcing current and therefore the incident energy levels. There are charts and calculators that will help even when site data is limited such as for circuit breakers and common European style fuses.

B. Prevent

A fundamental safety principle, which is embodied in European legislation, is to design out, eliminate or remove the hazard at its source. This leads to the conclusion that the majority of electrical tasks must be carried out with the equipment made dead. To work dead the electricity supply must be isolated in such a way that it cannot be reconnected, or inadvertently become live again, for the duration of the work. As a minimum this will include the positive identification of all possible supply sources, the opening and locking of suitable isolation points by personal padlocks and for the proving dead at the point of work.

Where the arc flash hazard cannot be eliminated then suitable risk controls should be in place (preventative or protective measures). The following chart illustrates that the relationship between hazard identification, deciding on suitable risk controls and the decision for work to proceed is an inter-dependent one. Furthermore, the physical task to be carried out on or near energized equipment is a very significant factor as it is usually worker activities that initiate a damaging arc flash event.

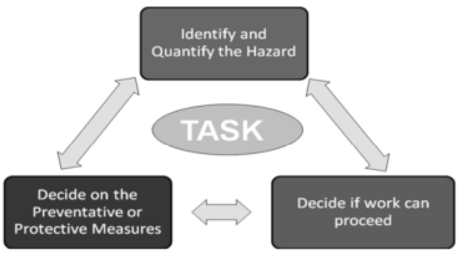

Figure 2. Hazard, Risk Control, Decision to Work [10]

To further clarify this relationship, a decision for work to proceed where there is a significant arc flash hazard cannot be taken in isolation of other factors. The level of hazard and also the availability and effectiveness of preventative or protective measures will also need to be considered. This effectively rules out a hierarchical approach which starts with the question: "What is the arc flash hazard?" then regardless of the task simply provide protection, usually through PPE.

The likelihood of an incident is greatly enhanced by poor worker competence and ignorance of the hazards. Common to this is the dropping of uninsulated tools or fastenings, sometimes out of breast pockets in clothing. Even for competent workers the loss of concentration, distraction and human error may be factors which lead to arc flash events.

Article 6(2) of European Council Directive 89/391/EEC EU Workplace Health and Safety Directive states "Where an employer implements any preventative measures, he shall do so on the basis of the principles" shown below.

(The author's interpretation of each of the nine principles of prevention when applied to the arc flash hazard is shown in italics)

- Avoiding the Risk – *which means Dead working, Not energized = No electrical danger*
- Evaluation the risks which cannot be avoided – *by arc flash assessment and predicting the level of harm and likelihood.*
- Combating the Risks at Source – *by designing out the arc flash hazard or reducing it to an acceptable level, even as a temporary measure for the period of work*
- Adapting to the individual –*limiting exposure to the hazard*
- Adapting to Technical Progress/Information – *take advantage of technological and technical progress to improve both safety and working methods. The evaluation of the hazard has progressed, as have mitigation and protection techniques in respect of arc flash.*
- Replacing the dangerous by the non dangerous – *Replace vulnerable legacy switchgear and control panels preferably with arc protected equipment and/or high levels of insulation and segregation of control and power circuits. Using safer equipment (e.g. test equipment) and tools (e.g. insulated)*
- Developing a coherent overall prevention policy – *create a <u>safe systems</u> approach which is specific to structure environment, workforce & equipment issues and developing risk based investment to reduce exposure to the hazard.*
- Giving collective protective measures priority over individual protective measures – *create a <u>safe place of work</u> approach by screening live parts and by good design. Any measure that is not dependent on the individual's choice.*
- Giving appropriate instruction to employees – *create a <u>safe person</u> approach by documenting safe systems of work and training employees in safe work practices. Highlight the arc flash hazard and provide information such as in the labelling of switchgear.*

It is important to note from the above list that PPE is not even mentioned!

These general principles of prevention should be considered against a hierarchy of risk controls with priority as given below. The top of the list should always take priority with PPE as a last resort.

- Elimination of the arc flash hazard
- Minimisation/engineering controls
- Safe Systems of Work
- Information and Training
- PPE

All these measures should be properly monitored and reviewed and this is particularly important when considering the lower order risk controls.

C. Protect

Where the risk cannot be controlled by prevention or where there is a residual risk of injury then it may be necessary to consider mitigation to prevent injury to the worker. The requirement for and suitability of mitigation techniques must form an essential element of any risk assessment.

Where protection against the thermal effects becomes necessary it must be emphasized that PPE does not prevent the accident happening in the first place.

Non flame resistant clothing may ignite or melt at lower incident energy values and once ignited will continue to burn after the electrical arc has been extinguished. Burning material next to the flesh can result in serious third degree burns even for very short durations. This means that ordinary clothing could actually become a hazard and for this reason it should be considered within the risk assessment. Similar to the U.S. practices, part of the risk assessment is to define the level of PPE that should be worn by the worker. However, the removal of the hazard is always the first choice.

D. Publish

Risk Assessments have to be recorded and may also require that field marking of equipment may be required. Safe systems of work, safety rules and procedures will be required and trained to all affected persons. It should be noted that labelling is not a mandatory requirement and here again it illustrates that the European approach is one where compliance is left to discretion of the Employer. This is all dealt with in the final step of Publishing. Warning signs must be standardized across Europe in a way which will minimize the potential problem that may arise from linguistic and cultural differences between workers. U.S. style labels based on ANSI Z535 are not acceptable as the colors and symbols do not conform to the European legislation.

Risk Assessments need to document the hazard severity and the risk control measures. Wherever possible these should be dynamically produced and task based. In other words, be available to the person carrying out the work who will reassess such things as environmental conditions and equipment state.

It should also be noted that the use of an Energized Electrical Work Permit would not be acceptable in the UK as Electrical Permits are restricted to dead working only.

Figure 3. Typical EU compliant field marking signs.

The words Warning and Danger are both on Yellow Backgrounds. Both labels contain some of the data printed with red text. The Warning label uses an exclamation point and some text on a blue background. The Danger sign contains white text in a red background.

VI. PPE TESTING PRACTICES

Testing practices used in Europe as well as many other countries are based on International Electrotechnical Commission (IEC) standards. There are two main test methods that are used for testing textile material and clothing.

IEC 61482-1-1 The "Open arc" test method [11] is used to test materials or assemblies which are then given a rating, expressed in kilojoules per square meter (kJ/m^2), which can be converted into the familiar cal/cm^2. IEEE 1584 incident energy calculations are frequently used and the arc rating is selected to be sufficient for the prospective incident energy.

IEC 61482-2-2 The "Box test" method [12] is based on the test methods originally developed in Germany. Instead of using an arc in open air, this method ejects the arc towards the test specimen from a plaster box and results in a more convective heat transfer.

The box-test standard defines two testing conditions known as Class 1 and Class 2 with each class based on a specific short circuit current during the test.

- Class 1 test uses a short circuit current of 4 kA
- Class 2 test uses a short circuit current of 7 kA

Figure 4. Box Test Set Up

Additional test parameters include:

Voltage:	400 volts
Frequency:	50 Hz.
Arc Duration:	500 ms
Distance:	300 millimeters (12 inches)
Electrode Gap:	30 millimeters
Electrodes:	Two opposing electrodes. Top electrode - aluminum Bottom electrode - copper

Protection that is tested in accordance with this standard will receive either a Class 1 or Class 2 rating which at the present time, is not officially linked to an arc rating. Therefore, the results of the open arc method and the box test method can not be directly compared so PPE has to be tested and assessed either with one standard or the other. Work continues with the refinement of this standard and also in developing practices for its use.

VI. ARC FLASH ACROSS INDUSTRIES IN EUROPE

There are still many variations in the way that the arc flash hazard is managed in Europe. Some industries are fairly well advanced while others lag significantly. The following generalization of the practices found in in different industries is purely the experience of the authors and not a result of definitive research.

Electric Utilities - Flame Resistant PPE is nearly universal in the Electrical Distribution Utilities although very few have carried out quantitative arc flash studies to identify the prospective incident energy levels. Among many companies, there is a risk balance approach where comfort of workers may be considered a higher priority than the worst case protection needs.

Generating Stations - Most generating stations have a high degree of awareness of the hazard and some have been providing FR PPE to their workers for many years. As a result, there has been an increase quantitative risk assessments among these facilities.

Petro Chemical Industries - A high level of awareness of the arc flash hazard exists, especially among the global oil companies. Many are now providing FR PPE to their workers.

Large Industry & Commerce - Generally there is a low awareness with this industry segment. However, U.S. and Canadian owned companies tend to promote global electrical safety programs that are often based on standards such as NFPA 70E and CSA Z462. As a result these companies recognize the need to protect workers but are unaware of the need to try to ensure that the approach will not conflict with local legislative requirements.

VII. HARMONIZATIONS OF STANDARDS

A great deal of work has been done on ensuring that electrical equipment is of a high standard. The European standards (ENs) backed up by the statutory European Directive 2009/104/EC concerning the use of work equipment will ensure that the very high specifications of control and switchgear will continue to be improved upon in Europe. For instance, the ingress protection standard for new control equipment with doors open is very rarely less than IP2X, which is finger safe. In other words, solid objects greater than 12mm cannot make contact with live parts because of enhanced insulation.

EN standards exist across all electrotechnical processes and equipment used within the European Union and many non EU countries as well. CENELEC (*Comité Européen de Normalisation Électrotechnique*) is the European Committee for Electrotechnical Standardization and is responsible for standardization in the electrotechnical engineering field. This covers the safety in operations as well as equipment specifications and EN 50110-1 Operation of Electrical Installations exists for this purpose. Here again however, there are no prescriptive standards for arc flash protection.

The vast majority of low voltage alternating current equipment at the point of use operates at 400 volts across all of Europe thanks to harmonisation. This is a standard distribution voltage and most energized work (and accidents) occur at this level. Approach boundaries outlined in NFPA 70E have less significance with European companies although some U.S. owned companies may insist that they are detailed on field marking of equipment.

VIII. CONCLUSION

Arc flash hazards and electrical safety issues are a global problem. At the present time IEEE 1584 and NFPA 70E greatly influence practices used by many companies worldwide. Although there are many similarities between practices used in the U.S. and other countries, there are also many differences. The authors continue to be actively involved in the development of European arc flash and electrical safety practices and IEC standards.

IX. REFERENCES

[1] EU Council Directive 1989/391/EEC *Workplace Health and Safety Directive "Framework Directive"*

[2] EU Council Directive 1989/656/EEC - *Use of Personal Protective Equipment*

[3] EU Council Directive 2009/104/EC - *Use of Work*

Equipment
[4] EU Council Directive 1992/58/EEC - *Safety and/or Health Signs.*
[5] Electricity at Work Regulations (EAWR) 1989 - Regulation 14 - Work on or near Live Conductors, Merseyside, England: Health Safety Executive
[6] S.I. No. 299/207 - *Safety Health and Welfare at Work (General Application) Regulations 86d - Precautions for Work on Electrical Equipment*, Dublin, Ireland: Health and Safety Authority
[7] Occupational Safety and Health Administration - Title 29, Part 1910, Subpart S, 1910.333 (a) (1) - *Selection and use of work practices*, Washington, DC: Department of Labor
[8] NFPA 70E, 2012 *Standard for Electrical Safety in the Workplace*, Quincy, MA: NFPA
[9] CSA Z462, 2008 *Workplace Electrical Safety*, Mississauga, Ontario: CSA
[10] 4P's and accompanying graphic used with permission from: DuPont Protection Technologies
[11] IEC 61482-1-1 - *Live working - Protective clothing against the thermal hazards of an electric arc - Part 1-1: Test methods - Method 1: Determination of the arc rating (ATPV or EBT50) of flame resistant materials for clothing*, Geneva, Switzerland: IEC
[12] IEC 61482-1-2 - *Live working - Protective clothing against the thermal hazards of an electric arc - Part 1: Test methods - Method 2: Determination of arc protection class of material and clothing by using a constrained and directed arc (box test)*, Geneva Switzerland: IEC

X. VITA

Jim Phillips graduated with a B.S.E.E. Degree from the Ohio State University and is Registered Professional Engineer. He is a member of the IEEE working group P1584 IEEE Guide for Performing Arc-Flash Hazard Calculations, Vice Chairman of IEEE 1584.1, and is a member of the P1683 Working Group. Jim is also a member of the IEC TC78, WG13 and IEC 61482-1-2 "Box Test Method" as well as many other national and international committees and organizations.

His career began in 1981 as a Power System Analysis Engineer at Square D Company. He then worked for Ohio Edison Company and was responsible for the transmission short circuit studies group. He also was on the adjunct faculty at Stark State College. Jim formed the training company now known as Brainfiller.com in 1987 as well as ArcFlashForum.com.

With a career spanning over 30 years, he has taught over 2000 training programs to people from all over the world. He has developed over 25 different training programs ranging from Protective Relaying to the NEC®, Arc Flash Studies, Symmetrical Components and more. He has authored numerous articles for technical magazines and is author of the book "Complete Guide to Arc Flash Hazard Calculation Studies" Jim continues to travel the world (typically flying over 150,000 miles a year) working with various U.S. and international standards organizations and speaking at many conferences and training events.

Mike Frain Having held senior management positions in contracting, utilities and facilities maintenance companies, Mike has put hundreds of people to work on a wide range of complex and large power electrical systems including being directly responsible for over 30,000 live working operations per year. He has authored electrical safety procedures & codes of practice and carried out arc flash assessments for many household names in industry, commerce and utilities in the UK and Ireland. Mike has advised many European and US owned companies on the compatibility of US standards with European legislation. He is the major consultant for the new European Arc Guide which is a unique risk assessment tool for arc flash based upon European Law.

Mike describes himself as a practical electrical engineer having started his working career as an apprentice contracting electrician in 1970 and obtained wide ranging qualifications to higher diploma level at the now called Sheffield Hallam University and Leeds Metropolitan University in England. He has participated in several working parties such as the Distribution Forum for the Centre of Vocational Excellence (CoVE) for the Power Industry. He was a member of the National Electrical Contracting Working Group who developed National Vocational Qualifications (NVQs) which form the basis for competence assessment for the electrical industry throughout the UK for the last 20 years.

Mike is a Fellow of the Institute of Engineering and Technology and a Corporate Member of the Chartered Management Institute.