

The Electrical Arc Flash Hazard

UK Cross Sector Research Project.
21st May – 20th July 2008.



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1. Executive Summary

The majority of serious injuries and fatalities from electrical incidents can be attributed to electrical arc blast & it's associated effects.

The reason for conducting this research project was due to the fact that there currently appears to be no definitive, single reference point as to the state of the UK industry's opinions, activities and future plans relating to the Electrical Arc Flash Hazard.

Therefore, as one of the UK's leading independent engineering consultancies within this specialist service sector, acting as an external RESPONSIBLE Expert, TAS commissioned and conducted the following project.

The key aim is to **share Best Practice** relating to the potentially fatal Electrical Arc Flash Hazard. Additional aims are to provide an up to date, definitive, documented study into the current activities & intentions of the UK's professional electrical engineering & safety management community, across all UK sectors.

An Electrical Arc Flash Study is not specifically identified as UK Legislation, but would fall into part compliance to Electricity at Work Regulations (E.A.W.R) 1989 – regulations 4 & 5.

Companies based in the UK, with a USA influence (Head Office or Safety Guidelines) also tend to work towards NFPA 70E standards – which actually calls for the use of PPE and specifies the need to conduct a detailed Electrical Arc Flash Assessment. The USA practice is well defined.

As UK engineering professionals are looking into keeping their site safe, their research has identified contrasts in the UK's requirements. UK legislation differs from USA standards, with more emphasis on mitigation of risk, and the use of PPE only as the last line of defence - in the last resort.

1.1 Key Findings

Arc Flash Risk Assessment Studies

1. Almost **half** (48%) of all respondents have **not** conducted an electrical arc flash assessment on their current systems (58% if the 'don't know' responses are included)
2. Of the 33% of the respondents who have conducted an Arc Flash Risk Assessment over the last five years, the key drivers / reasons for doing so were – in order
 - Compliance to UK regulations (Electricity at Work Regulations 1989)
 - USA Head Office / Safety Directive
 - In response to an Incident – their own or knowledge from another company
3. **43%** of the respondents who have experienced, or were aware of, an arc flash incident, have **not** conducted an Arc Flash assessment.
4. **57%** of the respondents who have experienced, or were aware of, an arc flash incident **responded in the correct manner** i.e. conducted all fault level studies & switchgear assessments, updated records & incident energy calculations, then identified correct F.R. Arc Related PPE requirements.
5. Respondents appear to place the updating of their systems records as a low priority when addressing a possible arc flash incident– however, this is incorrect and system updates should be placed as a high priority.
6. An equal amount of the respondents are planning to either conduct their own internal Arc Flash risk assessment, or to utilise external expertise to address the potentially fatal hazard

PPE (Personal Protective Equipment)

7. PPE (Personal Protective Equipment) appears to be the initial & primary choice activity of all respondents, to protect their workers from an incident.

The decision for this could fall into three categories

1. As a cost issue – driven by purchasing department / budgets.
2. Respondents appear to see PPE as a quicker solution to the problem of protecting staff from an electrical arc flash incident.
3. Understanding of an Arc Flash – it's causes, and the correct procedure to eliminate the risk.

*Some confusion currently reigns as American standards make the use of PPE mandatory - **P.P.E. should be the LAST line of defence to an Arc Blast in the UK.***

PPE (Personal Protective Equipment) /ctd..

8. PPE manufacturers & distributors generally tend to be the engineer / safety / operations manager's initial point of contact for sourcing solutions relating to protection against the Arc Flash Hazard. Therefore it is in their professional interest to make clients & prospects aware of the need to conduct an Arc Flash Study & related systems updates prior to calculating their PPE thermal value requirements to protect their workforce.

Training & Awareness Required

9. **59%** of respondents identified their future intentions relating to the Arc Flash Hazard is to ***'learn more & put a plan together'***. Therefore, a sustainable & proactive awareness campaign needs to be developed on a national basis via service provider professionals, PPE manufacturers / distributors, publishers, conference content providers & exhibition management organisations, in connection with Electrical Arc Flash, to develop & provide an understanding of the potentially fatal hazard.

TAS Offering Solutions

As a result and in response to the above – Finding 9 for the main required solutions, TAS Engineering is addressing the need to "Learn more about it and put a plan together for 2008", in four ways

1. Findings Update Presentations

To Share Best Practice, offering the presentation of this research document's findings, plus an engineering management analysis and summary of TAS's most recent x 15 Arc Flash projects (across numerous sectors) to companies, conference producers and professional associations.

2. In House Training / Awareness Courses

- A. Arc Flash Awareness Course - for all operatives, safety and general management who need to understand the causes, effects and impact of an Arc Flash incident.
- B. Engineering the Risk Out - A technical understanding and guidance course for Electrical Engineers who are looking to conduct their own in house arc flash risk assessments.

3. Online Networking Site

www.electricalsafetyforum.co.uk and www.arcflashforum.co.uk

For peer to peer networking and sharing Best Practice

4. Electrical Engineers Forum

Small regional road show / networking forums, with supplier & peer presentations, plus mainly facilitated discussions about attendee's current electrical safety issues.

1.2 Key Learning Points

1. There is a high professional responsibility on UK PPE manufacturers / distributors to educate the audience about steps to be conducted prior to the purchase of flame retardant, arc rated thermal value garments.
2. The advised route for Engineering & Safety Professionals to protect electrical workers from an incident is:-
 - Conduct a thorough Site Survey
 - Conduct Fault Level Study Calculations & Fault Clearance Times to IEC 60909
 - Identify all Protection Gradings
 - Update all Distribution System records
 - Conduct an Arc Flash Assessment to IEEE 1584 standards – this will identify calculated levels of cal. cm² PPE levels required for various kit and systems. Conduct assessment **before** contacting PPE manufacturer / distributor (to eliminate cost issues relating to incorrect purchase.)
 - Conduct a Switchgear Risk Assessment to HSG 230 -
 - Label & Identify Equipment.
 - Contact PPE Distributors / Manufacturers to selected products against the cal cm² criteria published in the Arc Flash Study report
 - Develop training and awareness of the Electrical Arc Flash Hazard for staff / operators
2. For new build & re designs of Electrical Switch Gear – it is recommended that remote switching is the chosen option – in order to take the operator away from the possibility of an electrical burn at HV.

1.3 Acronym Definitions

Acronym	Definition
Cal. cm ²	Calories per centimetre squared – (energy levels for PPE Protection.)
E.A.W.R	Electricity at Work Regulations 1989
F.R	Flame Retardant
HSG	Health & Safety Guidance
HSG 230	Keeping electrical switchgear safe.
H.V	High Voltage
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEC 60909 / BS EN 60909-0:2001	Short-circuit currents in three-phase a.c. systems. Calculation of currents
IEEE 1584	(TM)-2002 Guide for Performing Arc-Flash Hazard Calculations
IOSH	The Institution of Occupational Safety and Health
kA	Kilo Amps
LV	Low Voltage
MVA	Mega Volt Amps
NFPA 70E	National Fire Protection Association – USA Standard for Electrical Safety in the Workplace®
P.P.E	Personal Protective Equipment

2. Introduction

2.1 Defining an Electrical Arc Flash Incident

An electrical arc flash / blast, is a fault between 2 conductors – either Phase to Phase, or Phase to Earth, or any combination thereof...in high (HV) or low (LV) Voltage equipment.

Over 70 % of Arc-Flash incidents (in Europe) occur during or immediately after electrical maintenance, although NOT always. Old legacy H.V. equipment and high fault level L.V. equipment (that is frequently operated) are at HIGH risk, and there are many possible causes, with the key issues being:-

- Accidental contact by a worker or tool while working on energized equipment
- Mechanical breakdown, loose connections, and insulation failure – could be caused by unfinished or inadequate maintenance
- Dust build up between conductors
- Animals contacting energized components
- Current overload
- Voltage transients
- Equipment thought to be dead

The severity of an electrical arc flash, over a period of between 0.1 – 5 seconds approximately, depends upon the current path, duration and amount of energy or current flow, the variable effects for the human operator & employer could be:-

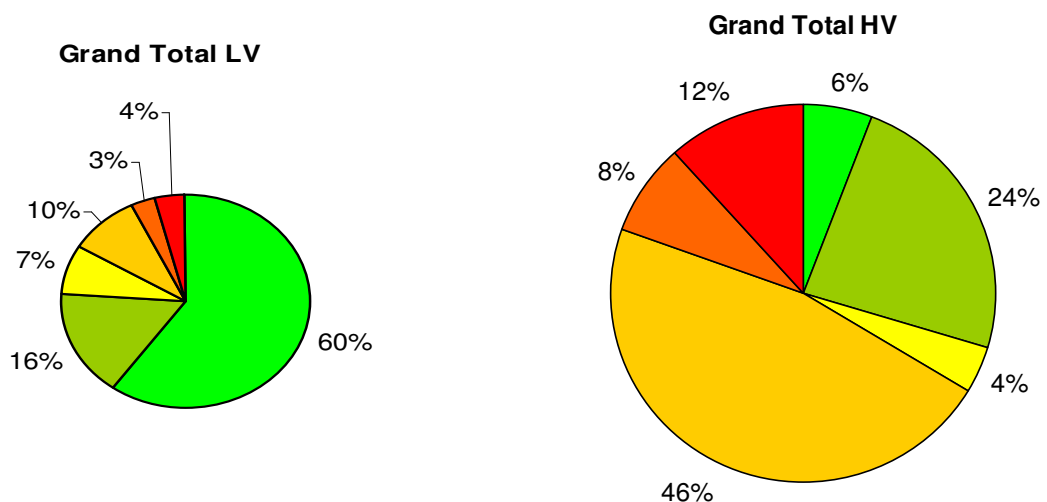
- Blinding light to the eye-temporary blindness
- Thermal heat 4 times that of the sun (35,000 degrees F)
- 2nd, 3rd, or 4th degree burns to unprotected skin caused by radiant and convective energy.
- Barotrauma – the effect of pressure waves on brain, nervous system and lungs.
- Sound at levels that could rupture ear drums.
- Molten metal that can splatter and burn into skin tissue.
- A toxic vapour cloud that can be inhaled into the lungs.
- Flying metal parts launched in all directions
- A pressure wave that will knock you down
- Equipment Damage /Loss of production
- Fire / Explosion Risks
- Damage to Corporate Reputation & Responsibility.

2.2 Background

An Electrical Arc Flash incident is not sector or size of system specific!

- Some people presume that Low Voltage Systems do not require an Arc Flash System Study. However, during a recent Arc Flash conference presentation – July 2008 by John Maplesden, Managing Director of TAS Engineering, some results surprised the audience. The presentation was an analysis summary of 15 studies conducted to IEEE 1584 standards (probably the largest published sample data in the UK to date). The results related to FR Category PPE requirements :-

Summary of x 15 Arc Flash Study Results – All Sectors



- 4% of Low Voltage switchgear studies (<1000V) results identified >Category 4 Dangerous PPE level requirements.**
- 12% of High Voltage switchgear studies (>1000V) results identified >Category 4 Dangerous PPE level requirements.**

2.3 Background General

Although the possibility of an electrical arc flash incident is always present in all industrial electrical switchgear & systems, since January 2007, there has been an increased demand from the UK professional market for education, awareness and understanding of the hazard. Evidence of this is via

- Number of TAS arc flash page views since July 2007 – July 08 – against previous year has increased by 85 %
- Inbound TAS arc flash & electrical safety related - enquiries & projects 2007 – 2008 against previous year risen by 150%
- UK Arc Flash & Electrical Safety fee paying Conferences x 4 in 07 - 08– Attendance at each between 55 – 140 attendees

The perceived key reasons for the upturn in request for information & understanding of the subject appears to be:-

1. Compliance to E.A.W.R. 1989 (Electricity @ Work Regulations) – in particular, regulations 4 & 5.

- **Regulation 4 (4) – Protective Equipment**

Status – Absolute

- *Any equipment provided under these Regulations for the purpose of protecting persons at work on or near electrical equipment shall be suitable for the use for which it is provided, be maintained in a condition suitable for that use, and properly used.*

- **Regulation 5 – Strength & Capability of Electrical Equipment**

Status – Absolute

- *No electrical equipment shall be put into use where its strength and capability may be exceeded in such a way as may give rise to danger.*

2. USA Head Office – or USA Safety Operational Standards Directives, working towards :-

- *OSHA 29 Code of Federal Regulations (CFR) Part 1910 Subpart S.*
- *NFPA 70-2002 National Electrical Code.*
- *NFPA 70E-2000 Standard for Electrical Safety Requirements for Employee Workplaces.*
- *IEEE Standard 1584-2002 Guide for Performing Arc Flash Hazard Calculations.*

3. Pro activity & Awareness of the arc flash hazard generated by UK based P.P.E (Personal Protective Equipment) Garment Manufacturers and Distributors.
4. Reaction to an incident – either their own, or knowledge of another company's incident.
5. Changes to the Corporate Manslaughter Act April 2008.

2.4 Survey Aims

The main aim was to collate a theoretically correct, unbiased report, which identified actual activities conducted to date – specific to the Arc Flash Hazard

This study was commissioned by TAS Engineering Consultants Ltd between May - July 2008, via data base mailings – qualified audience, awareness by industry specific publications and IOSH research site <http://www.oshresearch.co.uk/surveys.asp>

The aim of the study was to understand:

- Current awareness & understanding of the electrical arc flash hazard
- Arc Flash assessment activities performed to date
- Main reasons for performing an arc flash study
- Intended future activities in connection with the arc flash hazard
- Lessons Identified & lessons learned

The research was targeted at a qualified audience consisting of:-

- Electrical Engineers
- Responsible Engineers
- Engineering Managers & Directors
- Environmental, Health Safety & Compliance Managers
- Corporate Health & Safety Advisors
- Safety and Operations Directors

2.5 Methodology

Mailing to contacts / attendees (3,100) from :-

- TAS Dbase – previous clients & known prospects
- HazardEx Expo February 07 - <http://www.hazardexonthenet.net>
- HazardEx UK Road shows March – November 07 - <http://www.hazardexonthenet.net/hitr/index.html>
- Health & Safety Sandown & Bolton Expo 07 – 08 <http://www.healthandsafetyevents.co.uk/safetyevents08/home/-/>
- Arc Flash & Electrical Safety Conference Sept, Dec 07 – April 08
- COMAH Conference 08 <http://www.sieso.org.uk/index.htm>

Response Mechanisms

- Post
- Fax Back
- Online @ www.tas.co.uk/researcharcflash

Memberships & Associations – For additional awareness & information
IOSH <http://www.oshresearch.co.uk/surveys.asp>

Media / Publications Coverage :-

Processing Talk <http://www.processingtalk.com/>

Electrical Review <http://www.electricalreview.co.uk/>

Electrical Products & Applications <http://www.epaonthenet.net/>

Health & Safety Matters <http://www.hsmsearch.com/>

Safety & Health Practitioner <http://www.shponline.co.uk/>

2.6 Response Rate

- x 42 useable qualified data responses received.
- 249 page views of www.tas.co.uk/researcharcflash

A question has to be asked in this activity –

“As the **look rate** was considerably higher than the actual response rate, did potential participants choose not to respond, due to their lack of awareness or understanding of the subject?”

According to research conducted by TAS Engineering in June 2006, a definitive statement was identified which was reiterated by x 46 respondents and backs up the need for pro activity in informing the UK Engineering and Safety Management workforce about issues relating to their roles.

‘Mostly, I don’t have the time, or the staff to source everything internally, take time out of my working day to go to conferences or read about the up to date issues. Sometimes I don’t even know WHAT I need. I would prefer to partner with a company whom I can rely upon to provide me with the most up-to-date information on legislative issues and new innovations, who pre-empt my requirements, identifies new solutions and becomes my specialist advisor.’

(Prospect + Client Qualitative Research Respondents- June 2006)

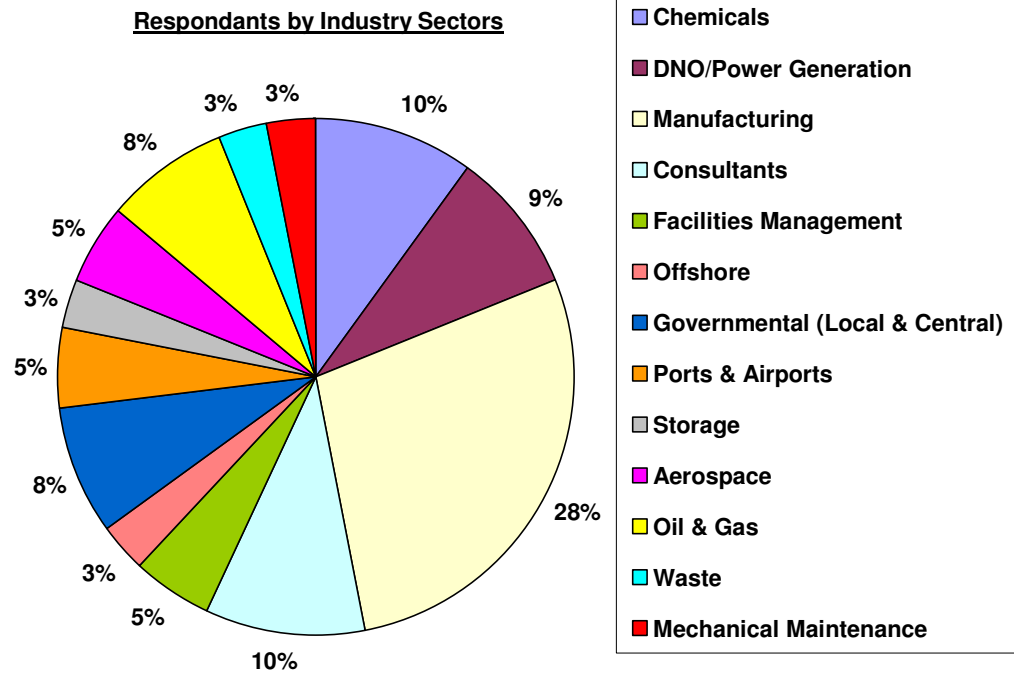
Therefore a possible answer to the above, would be that :-

A sustainable & proactive awareness campaign needs to be developed on a national basis, in connection with Electrical Arc Flash, to develop understanding of the potentially fatal hazard.

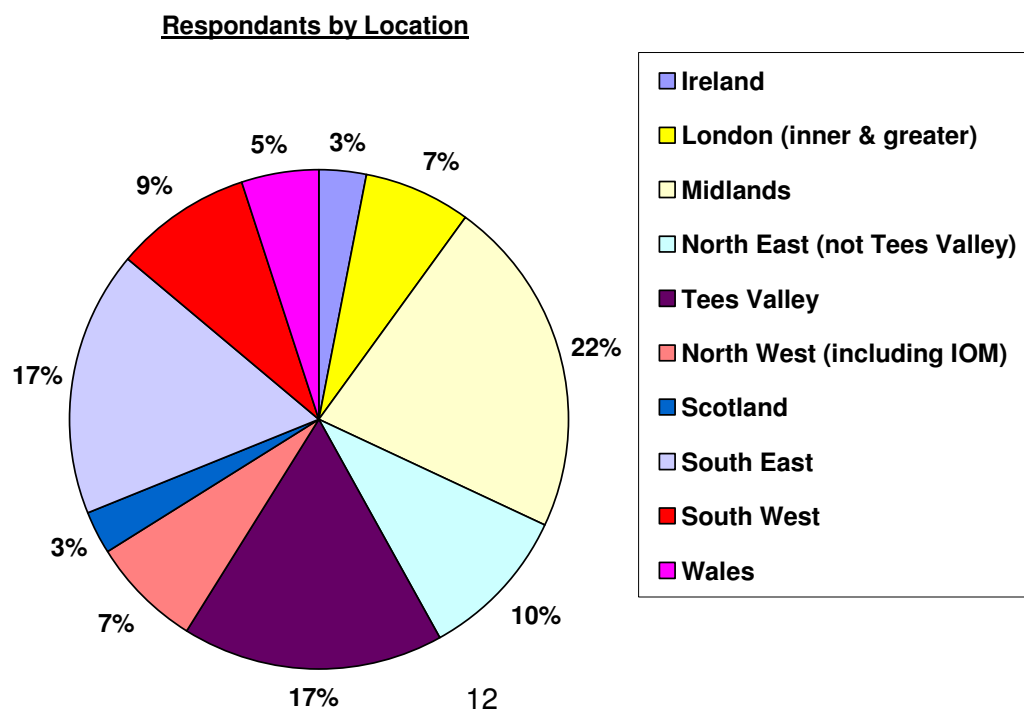
3. Main Findings

3.1 Respondent Data

By Industry Sector

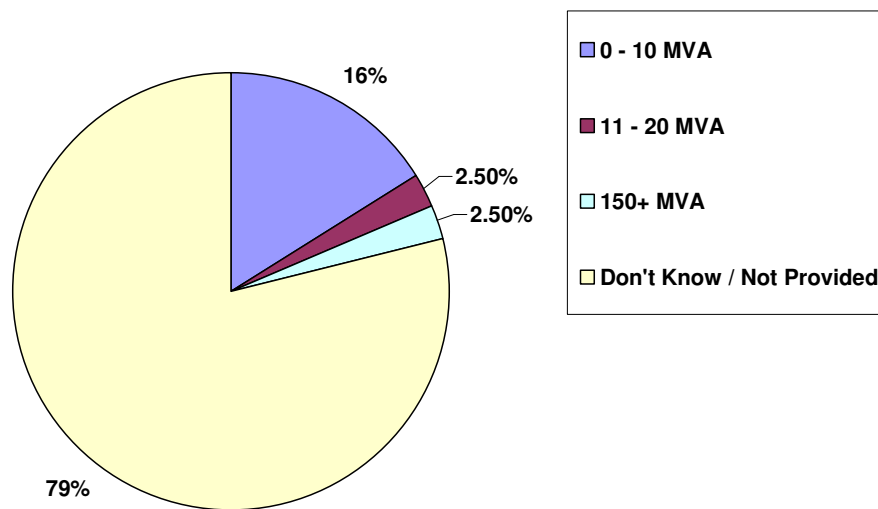


By Location



Size of Organisation as defined by Electrical Demand

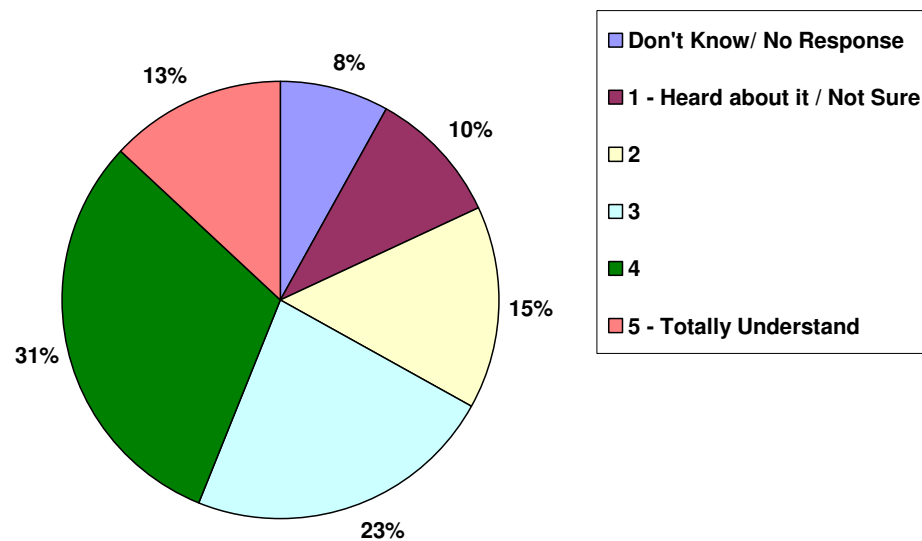
Maximum Electrical Demand (MVA - Mega Volt Amps)



3.2 Main Findings Responses

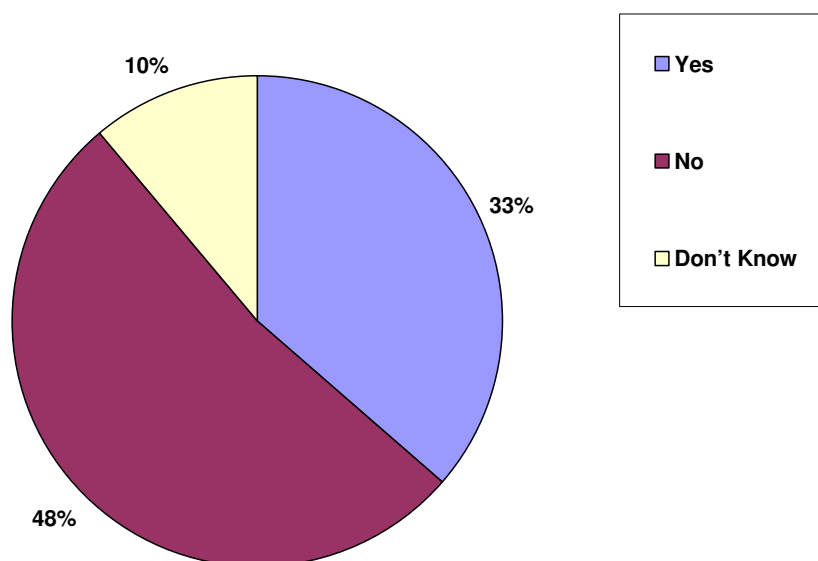
Q1. The Electrical Arc Flash Hazard - What is your current level of Awareness?

Q1 - Your current level of awareness of the Arc Flash Hazard

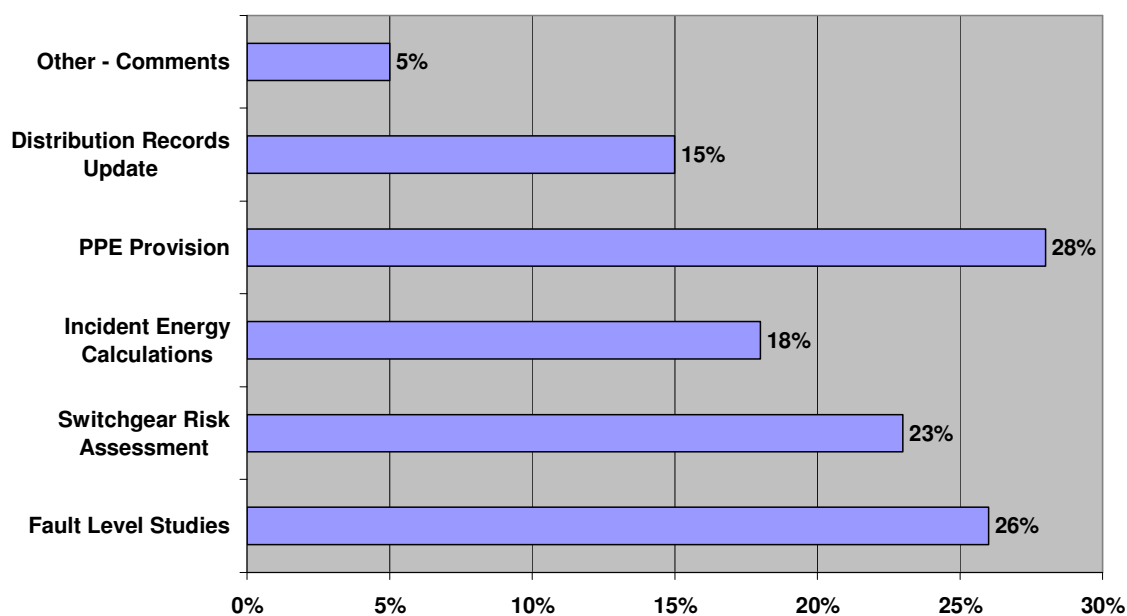


Q2. Have you / your organisation conducted an Electrical Arc Flash Assessment in the last 5 years?

Q2 - Have you or your organisation conducted an assessment in the last 5 years?

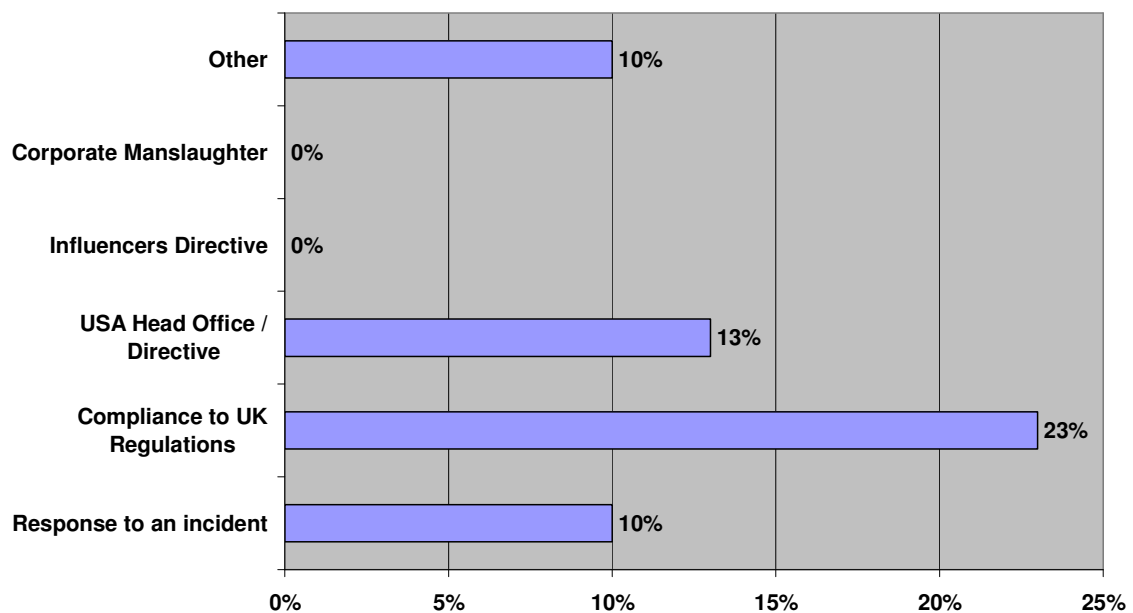


Q3. Please identify the activities carried out to date in your formal assessment. (multiple answers)



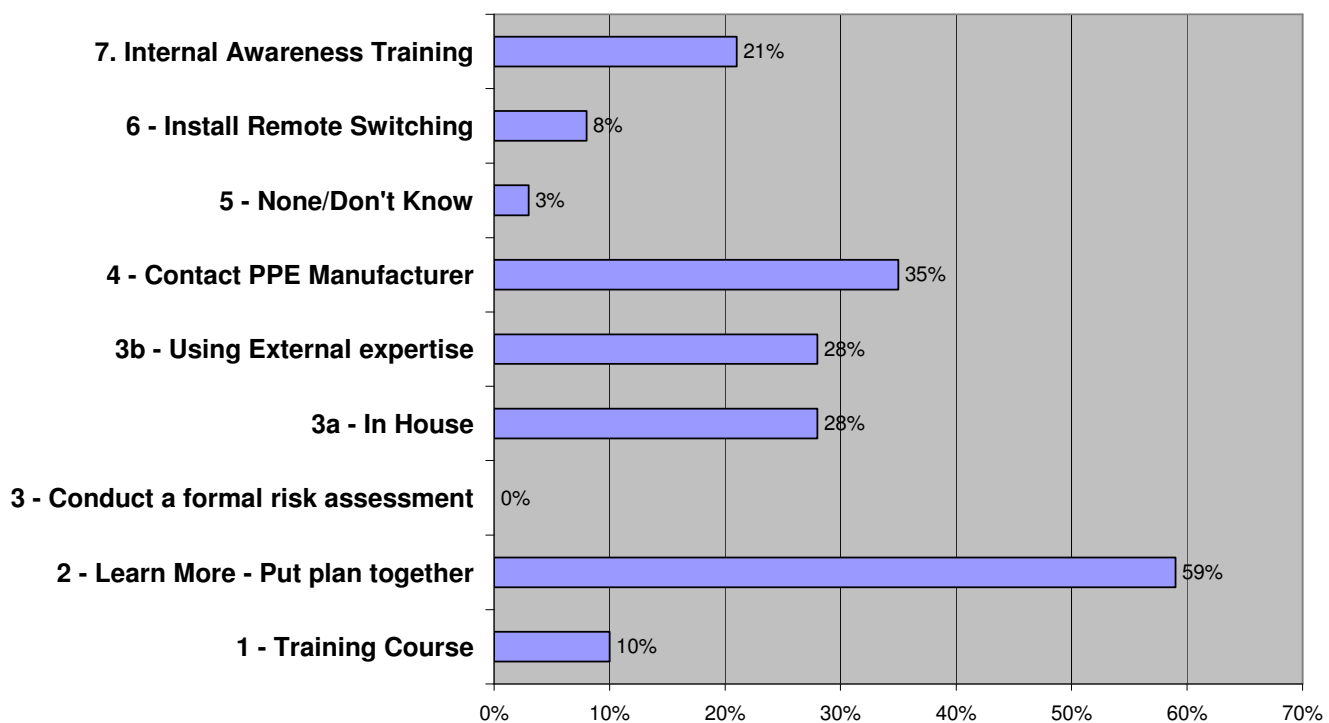
Q4. What was the main reason for conducting the arc flash risk assessment? (multiple answers)

Q4 - Main reasons for conducting the Arc Flash Assessment



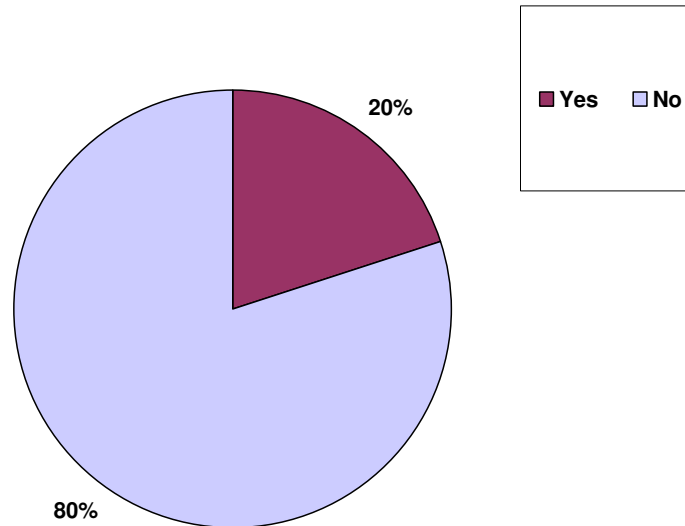
Q5. What are your future plans re: Electrical Arc Flash Hazard? (multiple answers)

Q5 - Future Plans re: Electrical Arc Flash Hazard



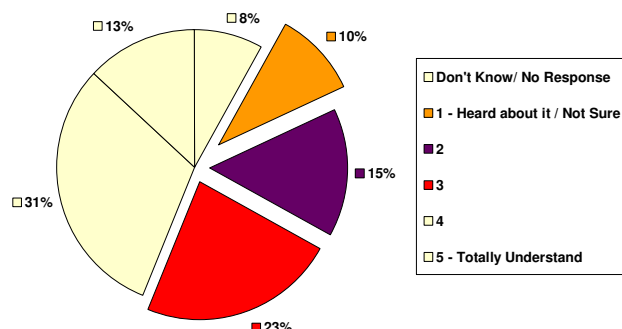
Q6. Would you like to share lessons learned re. Electrical Safety Incident?

Q6 - Would you like to share lessons learned re. Electrical Safety Incident



3.3 Advanced Analysis of Data.

Q1 - Your current level of awareness of the Arc Flash Hazard

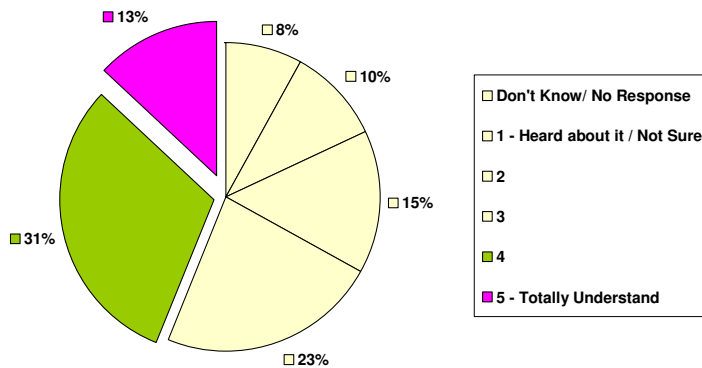


3.3.1 Understanding of the Arc Flash Hazard Levels 1- 3

Knowledge = Heard about it – to some knowledge.

- 48% of the respondents described their knowledge as 1- 3 (**Heard about it – to some knowledge**)
- Of the people identifying themselves as Levels 1-3, 20% have conducted an arc flash assessment in last 5 years – however
- 80% of these respondents have NOT conducted an Arc Flash Risk Assessment**
- Of those in this category, who's company **has** conducted an arc flash assessment in the last 5 years (20%)– the key activities addressed (in order)
 - 1st Fault level studies & Switchgear Risk Assessments
 - 2nd P.P.E Provision
 - 3rd Distribution Record Updates & Incident Energy Calculations
- Of those who's company **has** conducted an arc flash assessment in the last 5 years – the key **future plans** with regards to the Arc Flash hazard are to:-
 - 1st Contact PPE Manufacturer or Distributor
 - 2nd . Attend a training, course. Learn more and put a plan together for 2008. Conduct a risk assessment In House (Equal)
 - 3rd Conduct a risk assessment using external expertise.
- Of those who's company **has NOT** conducted an arc flash assessment in the last 5 years (80%) their key future plans with regards to the Arc Flash hazard are to :-
 - 1st Learn More & put a plan together
 - 2nd Conduct a Risk assess using external expertise
 - 3rd Contact a PPE Manufacturer or Distributor
 - 4th Conduct a risk assessment In House
 - 5th Train staff internally

Q1 - Your current level of awareness of the Arc Flash Hazard

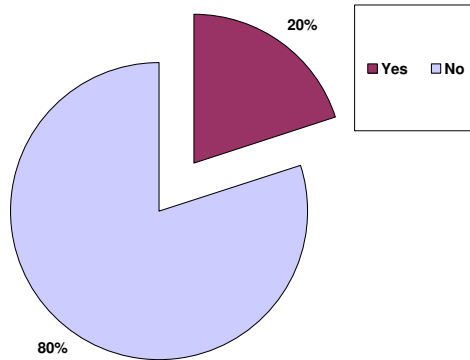


3.3.2 Understanding Arc Flash Hazard Levels 4-5

Knowledge = Good or Totally Understand

1. 42% of the respondents describe their understanding / knowledge of Arc Flash as 4-5 Good or Totally Understand
2. Of the people identifying themselves as **good or excellent.**, 56% have conducted an arc flash assess in last 5 years – however
3. **44% have NOT conducted an Arc Flash Assessment in last 5 years.**
4. Of those who's company **has** conducted an arc flash assessment in the last 5 years the key activities addressed (in order)were
 - 1st PPE Provision
 - 2nd Determine Fault Level Studies
 - 3rd Calculate Incident Energy levels
 - 4th Switchgear Risk Assessments
 - 5th Update Distribution Records – **this should be within the first 4 actions**
5. Of those who's company **has** conducted an arc flash assessment in the last 5 years – the **key future plans** with regards to the Arc Flash hazard are to:-
 - 1st Conduct an In House Risk Assessment
 - 2nd Contact PPE Manufacturer or Distributor
 - 3rd Develop staff & personal training / awareness
 - 4th Learn more about Arc Flash & put a plan together
 - 5th Install remote switching
6. Of those who's company **has NOT** conducted an arc flash assessment in the last 5 years (but their knowledge is **good or excellent.**) – the key future plans with regards to the Arc Flash hazard are to:-
 - 1st Learn More about Arc Flash & put a plan together for 2008
 - 2nd Conduct an in house risk assessment
 - 3rd Develop awareness training for all staff
 - 4th Contact PPE manufacturers / distributors

Q6 - Would you like to share lessons learned re. Electrical Safety Incident



3.3.3 Incidents Identified & Activities

1. 20% of all respondents provided information about an incident =
(listed as either Q6 response to an incident or sharing incident learning)
2. **A quarter of the 20% have not yet conducted an electrical arc flash risk assessment**
3. Of the three quarters who have had an incident **and conducted a risk assessment** In response, the key actions have been –
 - 1st PPE Provision
 - 2nd Switchgear Risk Assessment
 - 3rd Conduct Fault Level Studies
 - 4th Incident Energy Calculations
 - 5th Distribution Record Updates – last again...
4. 38 % say that they now totally understand about Arc Flash (level 5)
5. 38% say that their current understanding about Arc Flash is Level 3
6. Of those who have knowledge of an incident, their future plans are to
 - 1st Learn more about Arc Flash & put a plan together
 - 2nd Contact a PPE manufacturer / distributor
 - 3rd Conduct risk assessment in house (50%)
 - 4th Conduct risk assessment using external expertise (50%)

3.3.4 Lessons Shared

Sector / Company	Lesson Identified	Lessons Learnt
Water Company	Distribution hit cable in road & caused burns to operators	All distribution staff now have PPE
Power Generation / DNO	40kA Incident – minor burns	PPE was worn & fully fastened – despite it being a hot summers day
Quarry Manufacturer	Electrician stood too close to starter panel which exploded. Hi Vis clothing ignited & employee burned	PPE now in use
Safety Consultant	Non insulated screwdriver on consumer unit. It arced on metal framework	Use correct equipment & fully insulated tools

4. Appendices

4.1. The Research Questionnaire

Over the last 10 years, TAS has been providing Electrical Arc Flash Studies Services to UK based organisations.

For the future, we would like to help you & your organisation share '**Best Practice**' of UK wide **Electrical Safety** intelligence with industry peers, by providing awareness campaigns via industry publications, associations and conferences. In order to gain current market intelligence & opinions, *may we ask for your help.* **Complete anonymity is ensured.** The aim is to collate this data and share it with the UK professional community of National Engineering, Safety & Compliance Managers via Industry Specific :-

- White Papers / Published Articles– Sharing findings & identifying future 'Best Practice'
- Conference, Seminars, Road Shows & Peer Forums – UK wide

We are providing an impartial incentive draw 20th July 08– where your entry could win:-

- £250 Donation – to the Charity of your choice – or
- Driving 'Experience' Day – At a UK racetrack.

Many thanks for your input – it is very much appreciated.. If you have any questions, please call my **direct dial 01642 732151** Beverley Rose – Marketing Manager – beverley.rose@tas.co.uk

Q1. The Electrical Arc Flash Hazard – What is your current level of awareness / understanding of the causes, effects & methods to reduce the risk? (please tick)

1 =Heard about it, but not sure of specifics to 5= I totally understand

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Q2. Have you / your organisation conducted an Electrical Arc Flash Assessment in the last 5 years ? (please tick)

☐ Yes ☐ No (please go to Q 5) ☐ Don't know(please go to Q 5)

Q3. Please identify the activities carried out to date in your formal assessment

☒ Fault Level Studies	☒ Switchgear Risk Assessments
☒ Incident Energy Calculations	☒ PPE Provision
☒ Distribution Records Updates	☒ Other – please comment..

Q4. What was the main reason for conducting the Arc Flash assessment?

☐ In response to an Incident (your own or another company)	☐ Other please comment:
☐ Compliance to UK Statute / Regulations	
☐ USA Head Office or USA Directive	
☐ Influencer's Directive i.e. insurers	
☐ Corporate Manslaughter Act Changes	

Q5. What are your future plans re: Electrical Arc Flash Hazard ?

- | | |
|---|--|
| ☐ 1. Attend Training Course | ☐ 4. Contact PPE Manufacturer / Distributor |
| ☐ 2. Learn more & put plan together for 2008 | ☐ 5. None / Don't know |
| ☐ 3. Conduct a formal risk assessment | ☐ 6. Other – please list |
| ☐ 3a. In house | |
| ☐ 3b. Using external expertise | |

Q6. If you would like to share an Electrical Safety Incident / Learning Experience – please list below. (this data could be used for sharing 'Best Practice' in peer to peer forums & articles – please tick if you wish to contribute anonymously)

- | | |
|--|--|
| ☐ Please keep all my details anonymous | ☐ I am happy to be identified as a contributor . |
| Lessons Identified | Lessons Learnt |

Q7. Your Location (please tick)

- | | | | | |
|--|-------------------------------------|---------------------------------------|-----------------------------------|-------------------------------------|
| ☐ Scotland | ☐ North East | ☐ North West | ☐ Midlands | ☐ South East |
| ☐ London (inner / greater) | ☐ South West | ☐ Other – list | | |

Q8. Your Maximum Electrical Demand (MVA)– please list.....

Q9 Please identify your business sector -i.e. Oil ☐ & Gas, Manufacturing
.....

Q 10 – Electrical Safety /Arc Flash Forum.

Please tick here & list your details below If you are interested in sharing 'Best Practice' with your industry professionals & peers via online forum site & face to face regional quarterly / bi annual forum meetings. List issues that you would like to see addressed during online & face to face electrical safety / arc flash forums:-

Q11 - Prize Draw & your details

- ☐ £250 Donation – to the Charity of your choice – please list charity.....
- ☐ Driving 'Experience' Day – At a UK racetrack.
- ☐ I do not wish to be entered into the prize draw
Please complete the following & **FAXBACK both pages to 01642 616480**

Your Name.....

Company Name.....

Email..... Telephone Number.....

5. Acknowledgements

Many thanks go out - not only to the respondents of this insight project, but also to the industry specific editors and responsible professionals who created more awareness and encouraged potential respondents to take part.

Memberships & Associations – For additional awareness & information
IOSH <http://www.oshresearch.co.uk/surveys.asp>

Media / Publications Coverage :-

Processing Talk <http://www.processingtalk.com/>

Electrical Review <http://www.electricalreview.co.uk/>

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