

Analysis of Reported Electrical Incidents & Complaints

2005-2008

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High Voltage (HV) and Low Voltage (LV) Electrical Burn Incidents



High Voltage Incidents

Examples from other sources:

- Case: burnt arm

Current entry & exit wounds due to contact with high voltage conductor

- Case: burnt feet

Victim contacted live high voltage with current exiting via his feet



High Voltage Incidents

- Case: person exposed to arc flash
Burns to most of body



Low Voltage Incidents

- **Case:**
 - Electrician with 30 years experience attempted to connect a Sub Circuit to a live, high energy switchboard.
 - Inadvertently short circuited a Live Circuit resulting in significant Arc Flash.
 - Electrician suffered burns to exposed arms, neck & throat.



High Voltage Incidents

- Causes

- Victim's failure to maintain safe approach distance from live HV conductors.
- Victim improperly protected from HV Arc Flash .
- Victim not using approved and tested safety equipment, such as insulated mats & footwear.



Electric Hazards from Direct Contact

- **Human body conducts electricity**

Current through the body depends on body resistance (Ohm's Law).
Body resistances are very high but can fall as low as 200-300 Ohms

- **Electric shock effects depend on**

- type of circuit
- its voltage
- resistance and amperage
- the pathway through the body
- duration of the contact

Electric Hazards from Direct Contact

- Sudden Shock

Table 1.

Band	Shock Current	EFFECT (sudden shock)
1	Below 0.5 mA	No perceptible effects
2	0.5 – 2 mA	Tingling
3	2 – 5 mA	Sharp pain, shock not dangerous, nervous system affected
4	5 – 20 mA	Cannot release grip
5	20 – 50 mA	Waste products start to build up in blood, irreversible change to brain cells
6	50 – 1000 mA	Fibrillation in addition to all the above, death within minutes
7	Above 1 Amp	Bad tissue burns, death quickly

Electric Hazards from Direct Contact

- The effects in the previous table are for a sudden shock.
- “Safe voltage” at 200-300 Ohm is approx 10-15V based on 5mA.
For a voltage of 55V with 200-300 Ohms, the current is 18.3 - 27.5 mA.
This is in the dangerous region (bands 4 & 5, Table 1)
- The effects will be magnified with time when catching a live conductor.
- Electric burns are a result of current flowing in the tissues. They may be either skin deep or penetrate to deeper layers, or both.
- Electric burn hazards are experienced from proximity to arcs resulting from short circuit or current interruption.

Mitigation of Electric Shock

- use of RCDs

- Residual Current Devices (RCDs) are designed to prevent electrocution by detecting earth leakage current.
- Leakage current is of typically 5–30 mA
- Smaller than trigger currents needed to operate conventional circuit breakers, typically measured in amperes.
- RCDs are intended to operate within 25–40 milliseconds, before electric shock can drive the heart into ventricular fibrillation, the most common cause of death through electric shock.



Electrical Shock Protection

- **An RCD helps to protect against some electric shocks:**
 - where current flows through a person from a phase (live/line/hot) to earth.
- **An RCD is ineffective:**
 - where current flows through a person from phase to neutral (Ph-N)
 - where current flows through a person from phase to phase (Ph-Ph)
e.g. finger touches both live and neutral contacts in a light fitting.
 - in insulated electrical systems
- **Protection against electrical shock of Ph-N and Ph-Ph must be through**
 - **mechanical means** e.g. guards or covers to protect against accidental contact
 - **procedure** e.g. switching off power before undertaking maintenance.

Electrical Incidents

- Damage due to an Electric Fault

Examples of Electrical Fault Damage to Equipment



Damage due to an Electric Fault

Case: CB failed to break fault current resulting in large explosion

Case: Severe damage to rear panel of metal-clad Switchboard



Damage due to an Electric Fault

Sudden pressure increase inside sub station blew out walls causing roof to collapse



Protection of Equipment Against Electrical Faults

- Overloads leading to fires and/or shock can be mitigated through use of
 - Overcurrent protection relays
 - Fuses
 - Devices that are a combination of RCDs and Circuit Breakers
i.e. Residual Current Circuit Breaker with Overcurrent Protection (RCBOs)



Analysis of Reported Electrical Incidents 2005-2008

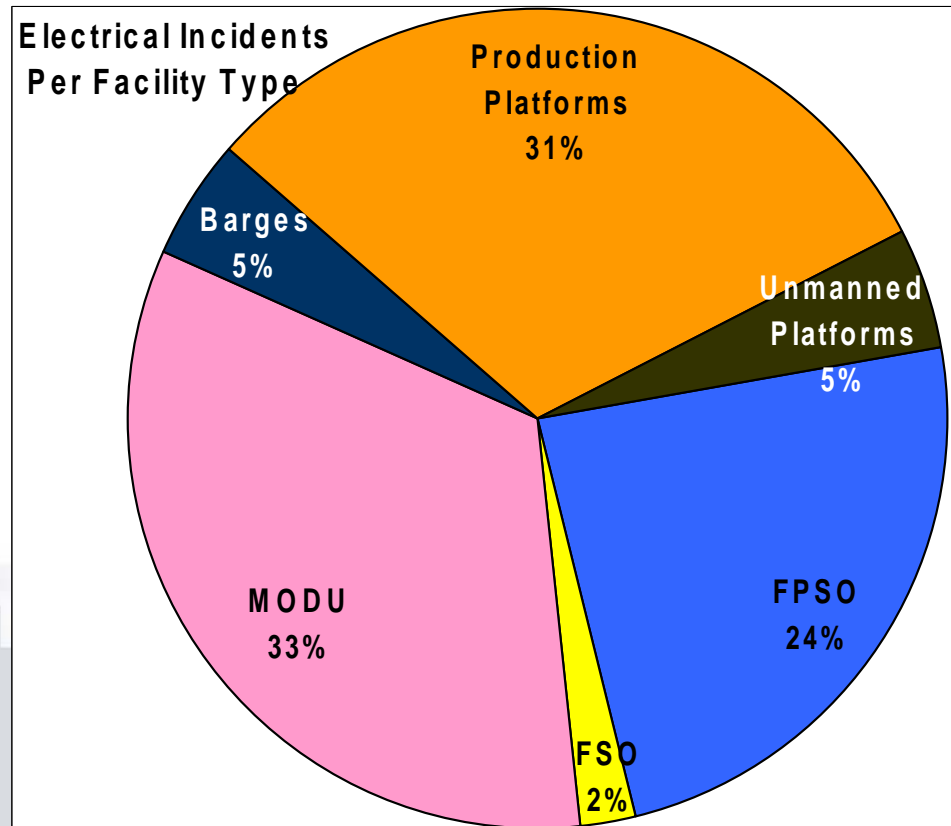
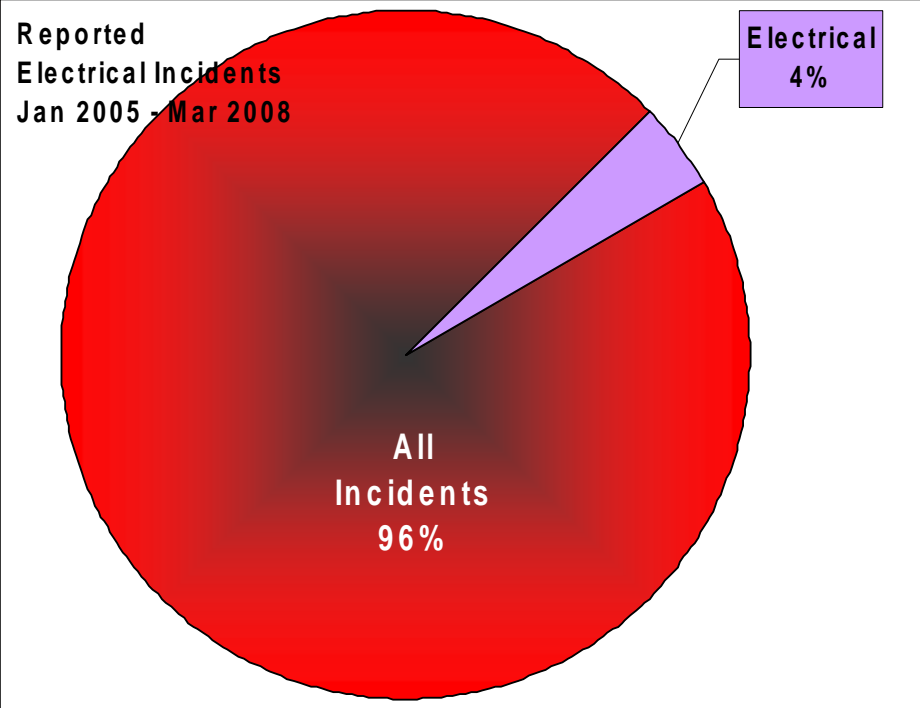
Data Analysis



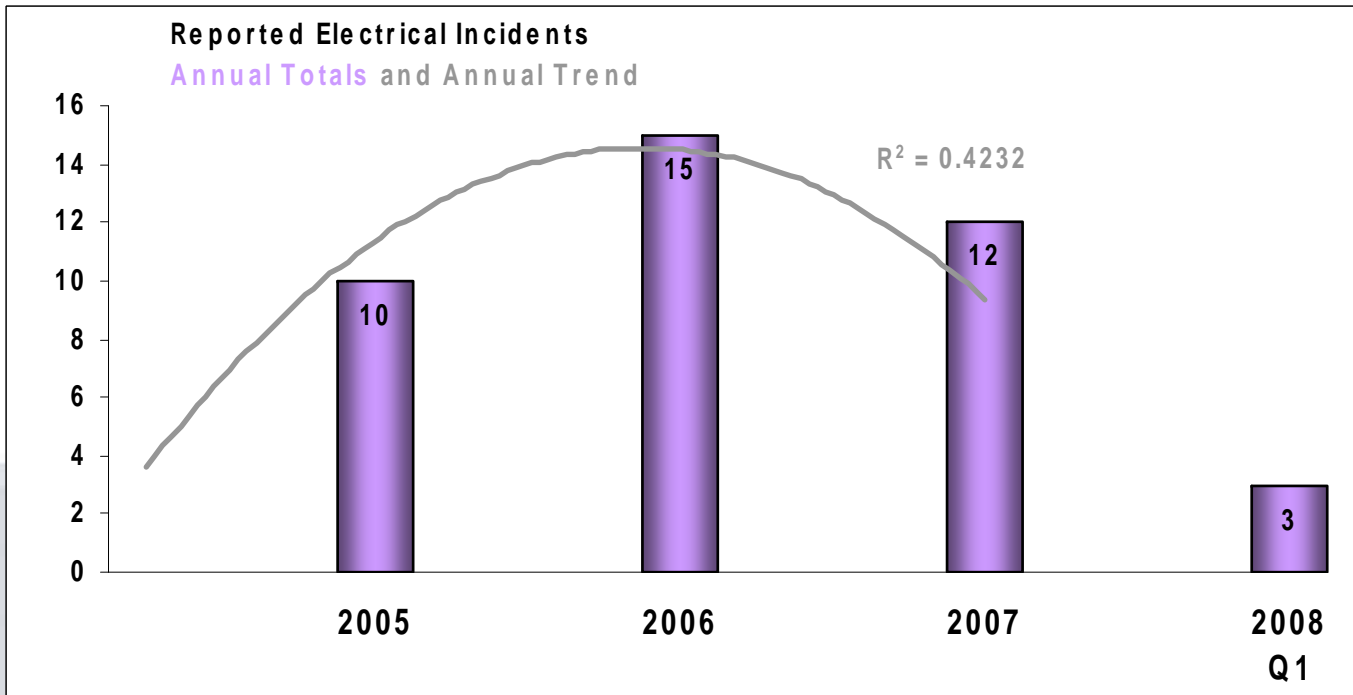
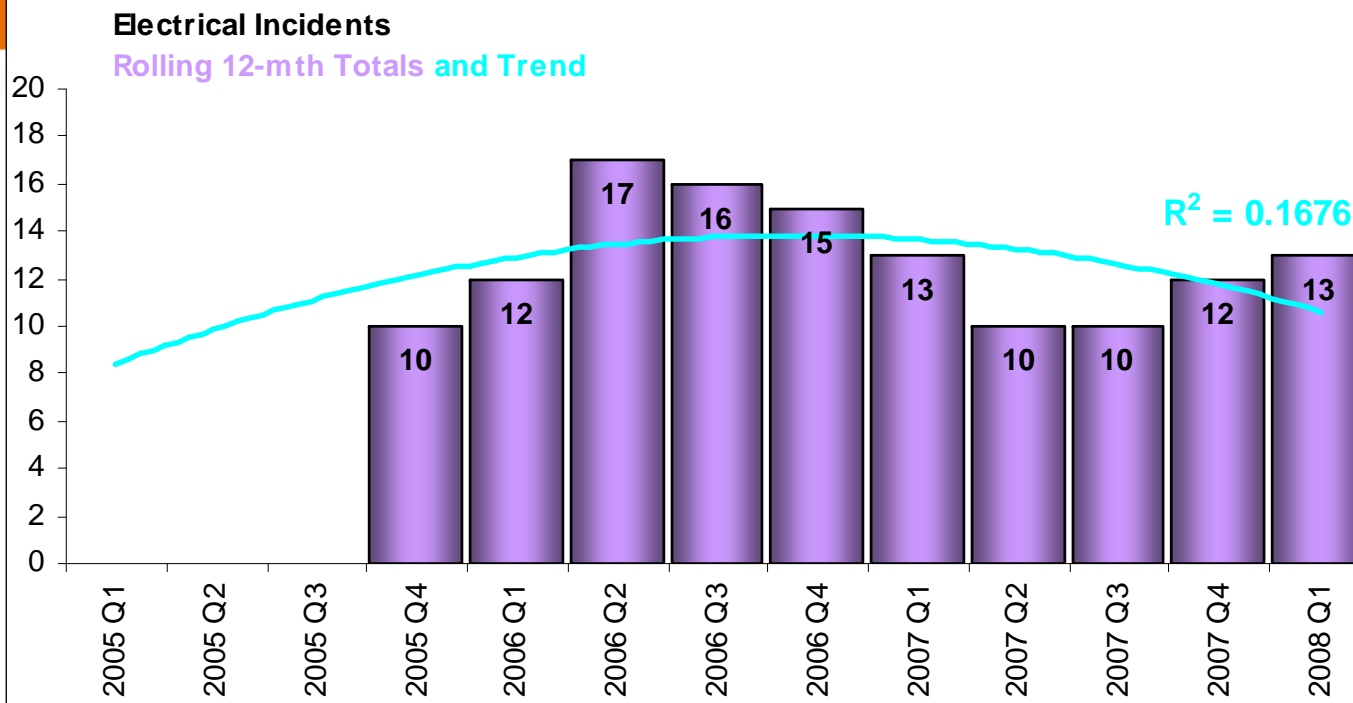
Reported Incidents 2005 - 2008

Proportion of Electrical Incidents

Percentage of Electrical Incidents per Facility Type



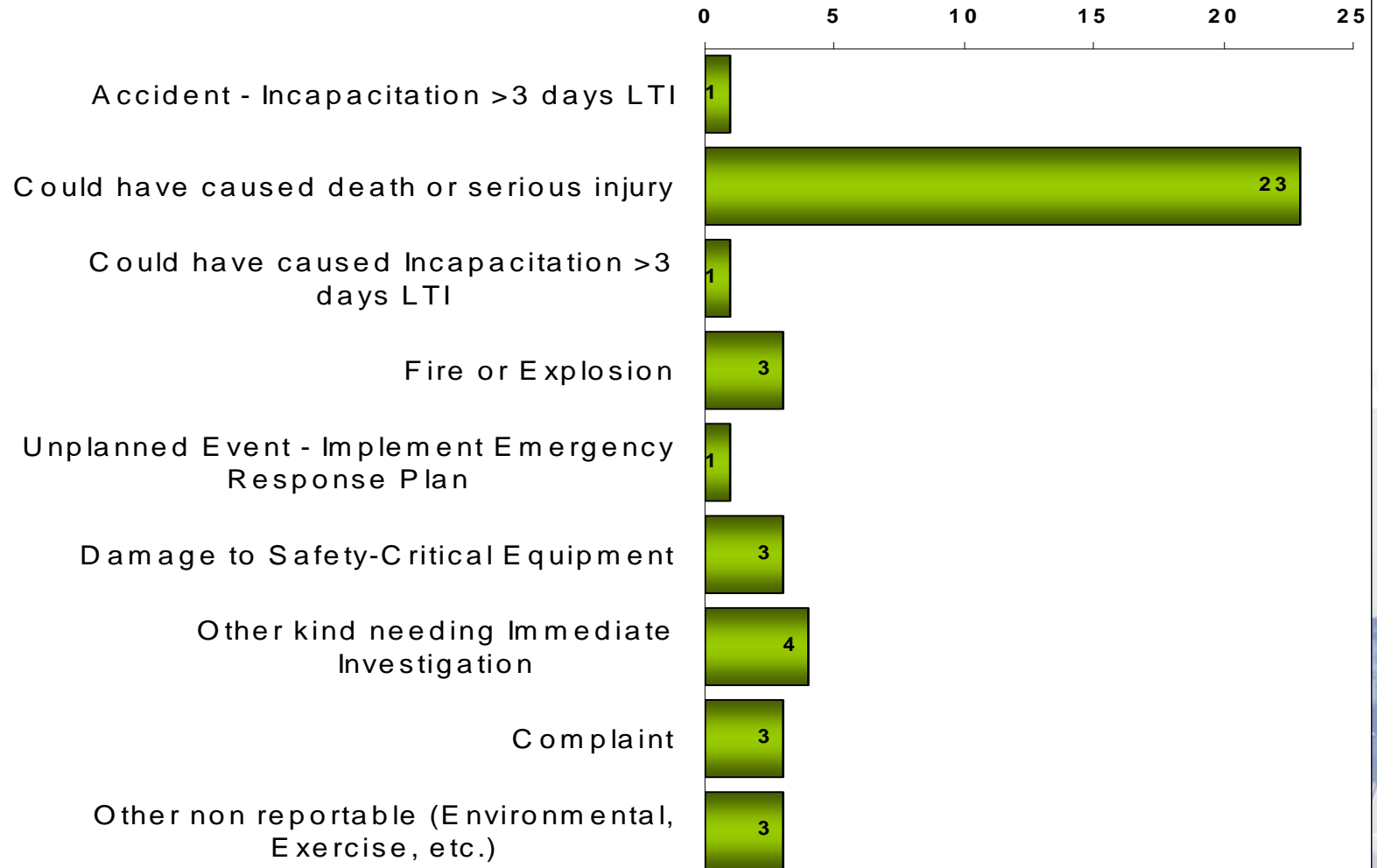
Electrical Incidents Totals



Electrical Incidents Reported

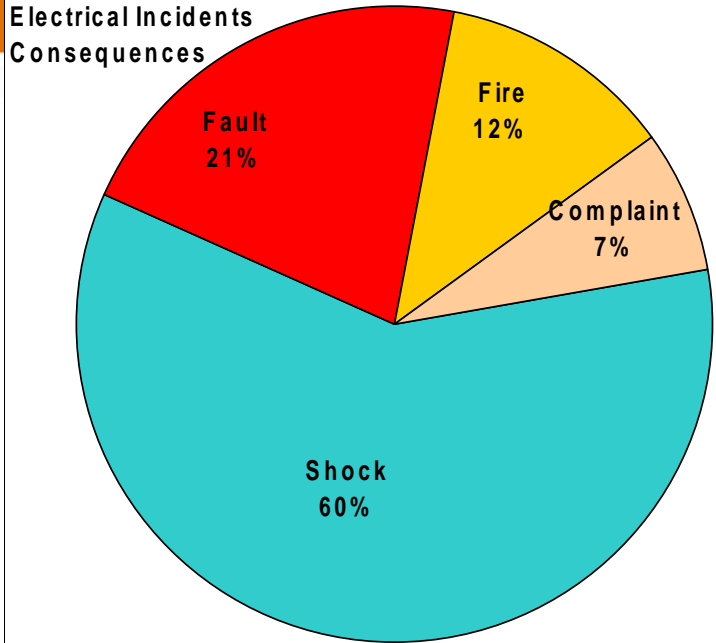
MoSOF Reg 45 Categories

Electrical Incidents - MoSOF 45 Categorisation



Electrical Incidents & Complaints

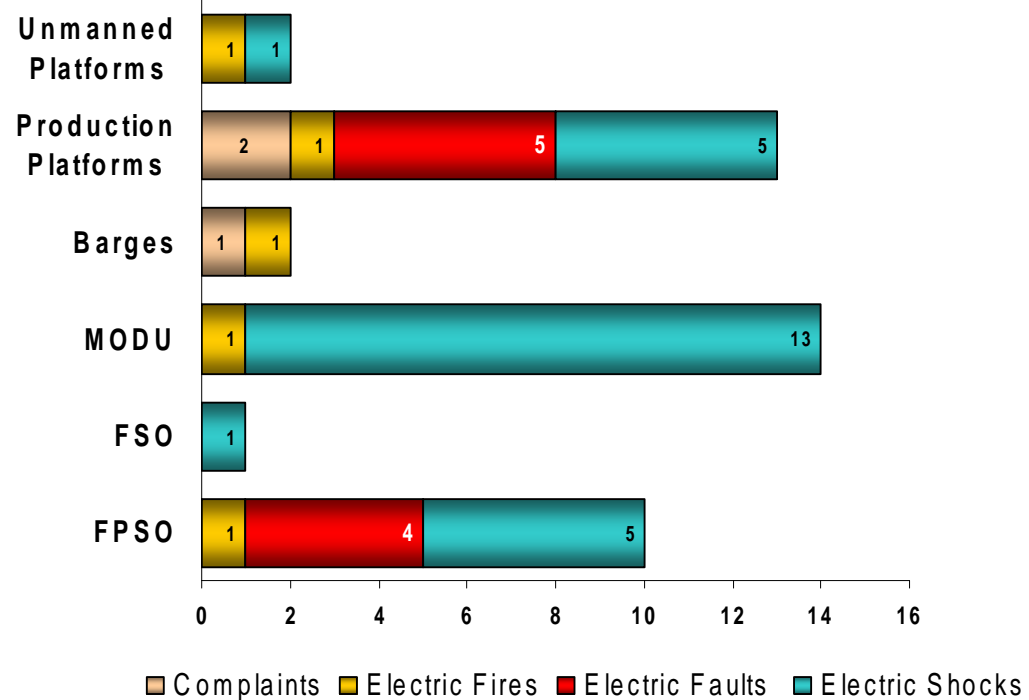
Consequences



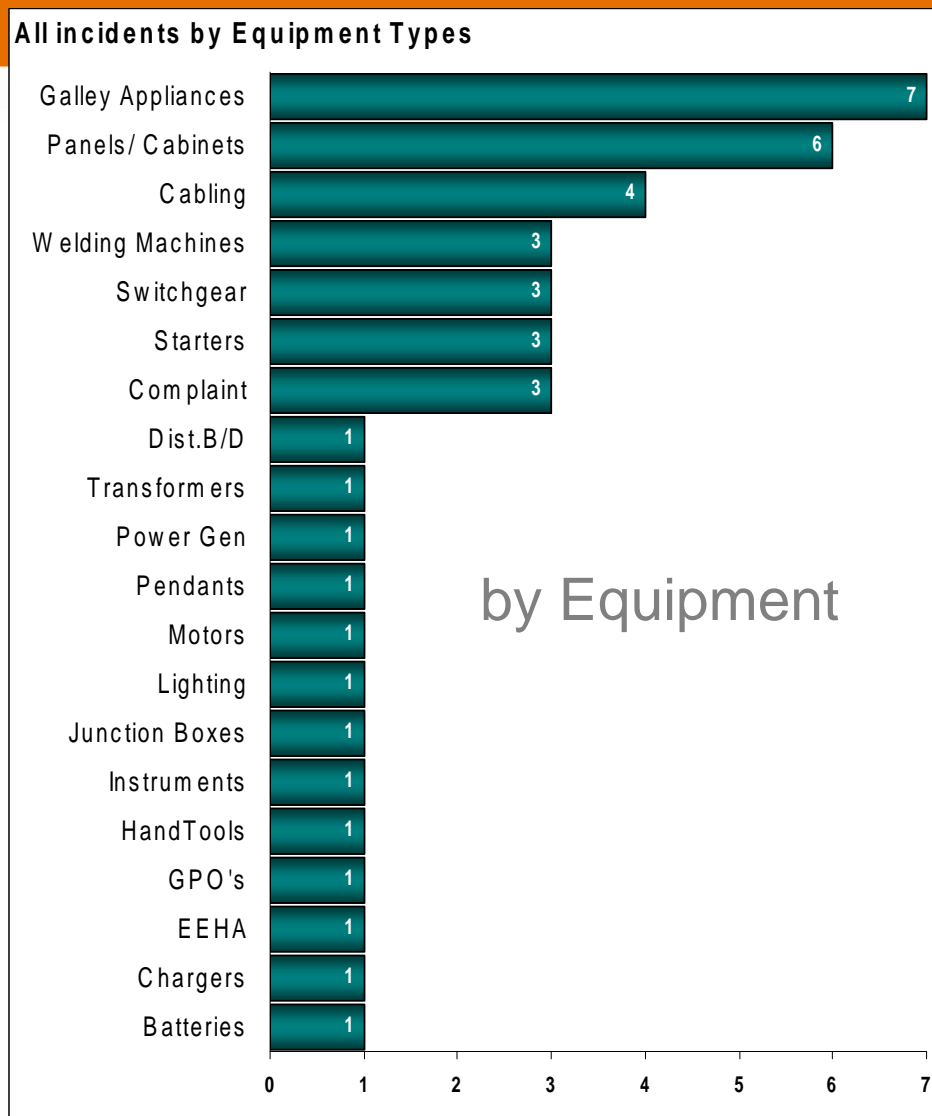
Consequences per Facility Types

Consequences of Electrical Incidents classified into :

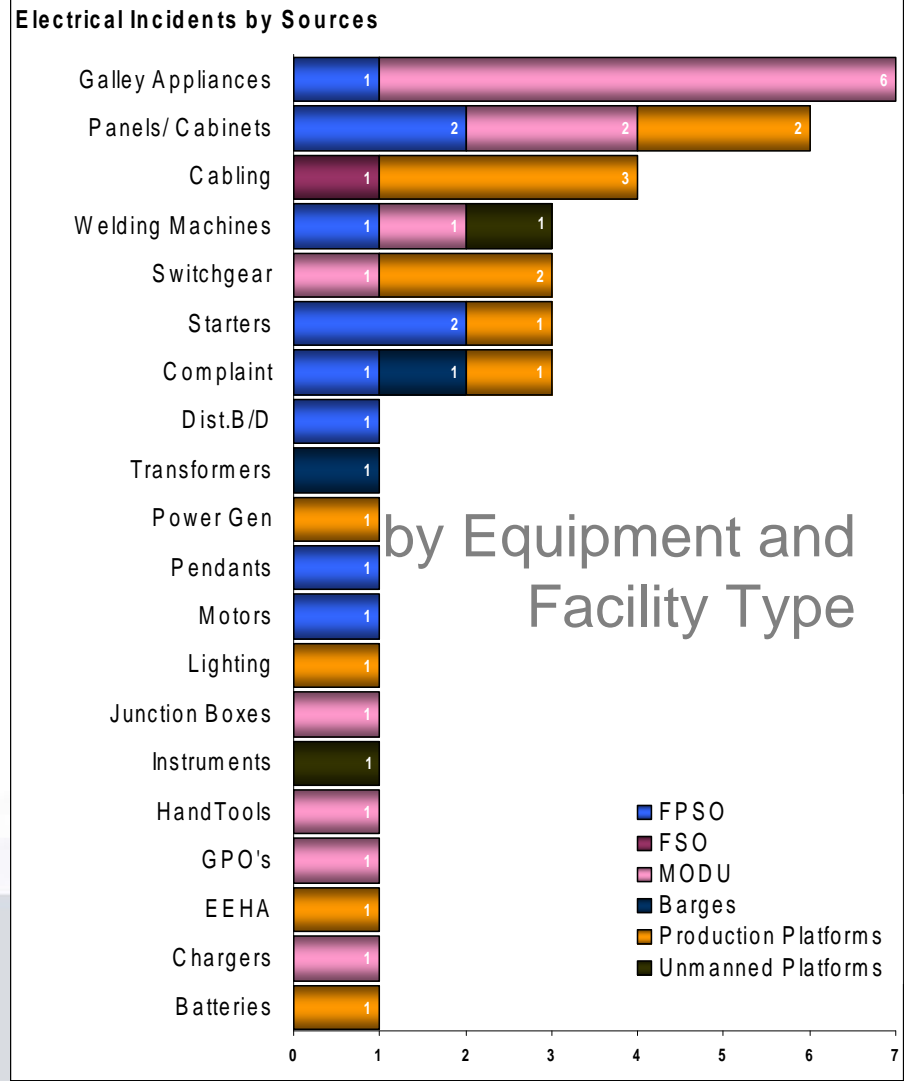
- Electric Shocks
- Electric Faults (Equipment damage)
- Electric Fires
- Misc (including Complaints)



Electrical Incidents



by Equipment

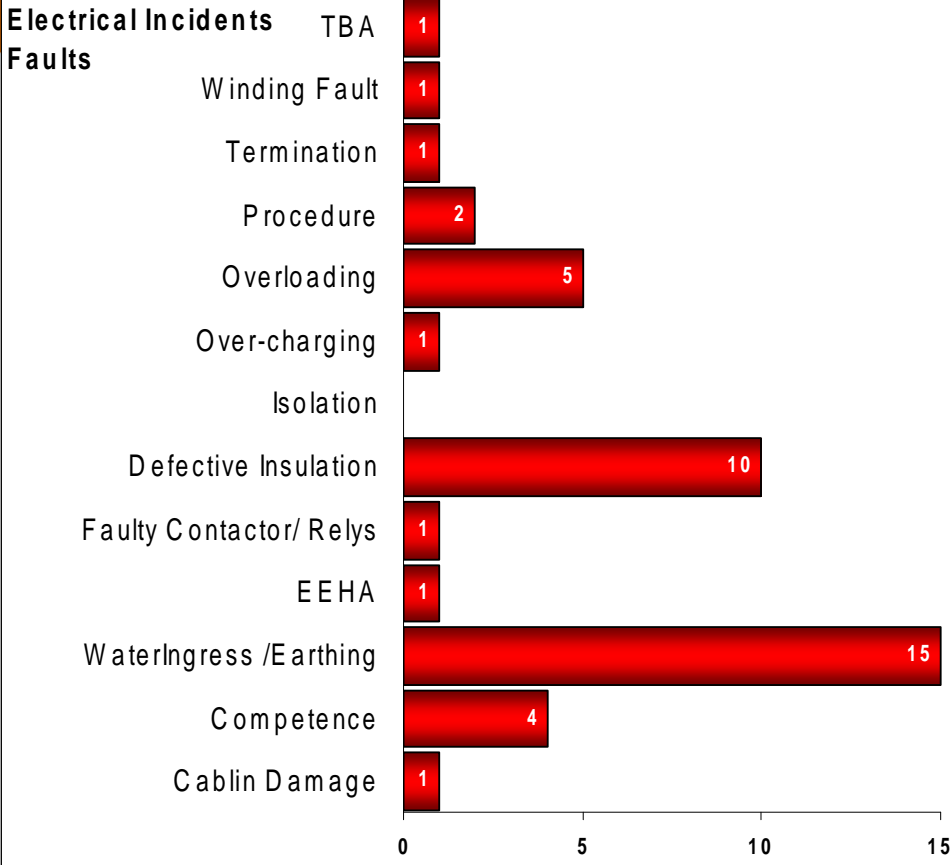


by Equipment and Facility Type

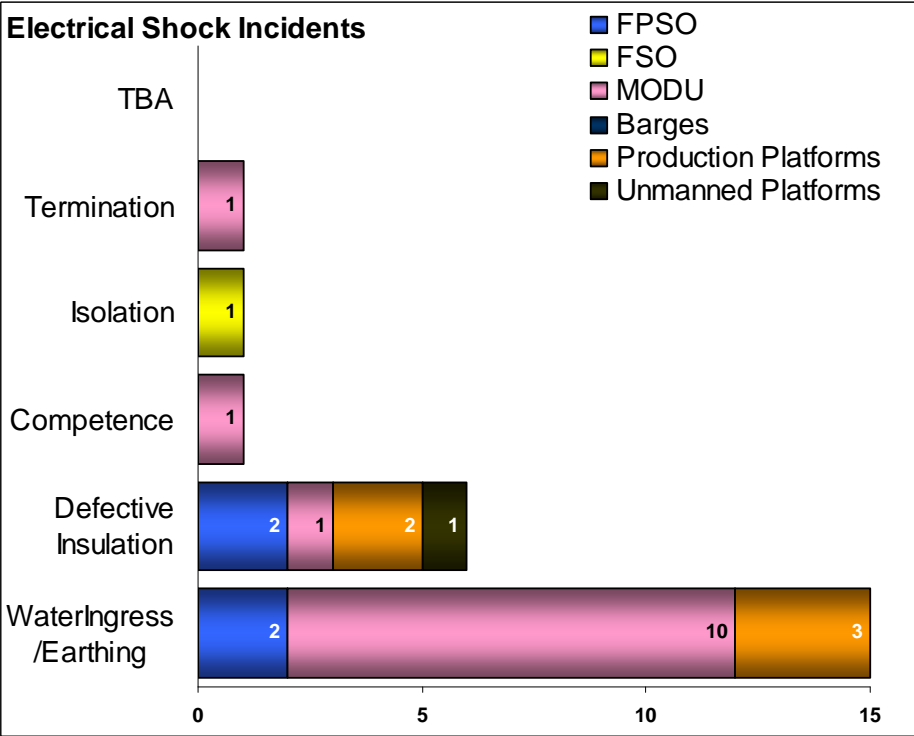


Electrical Incidents

by Fault Causes

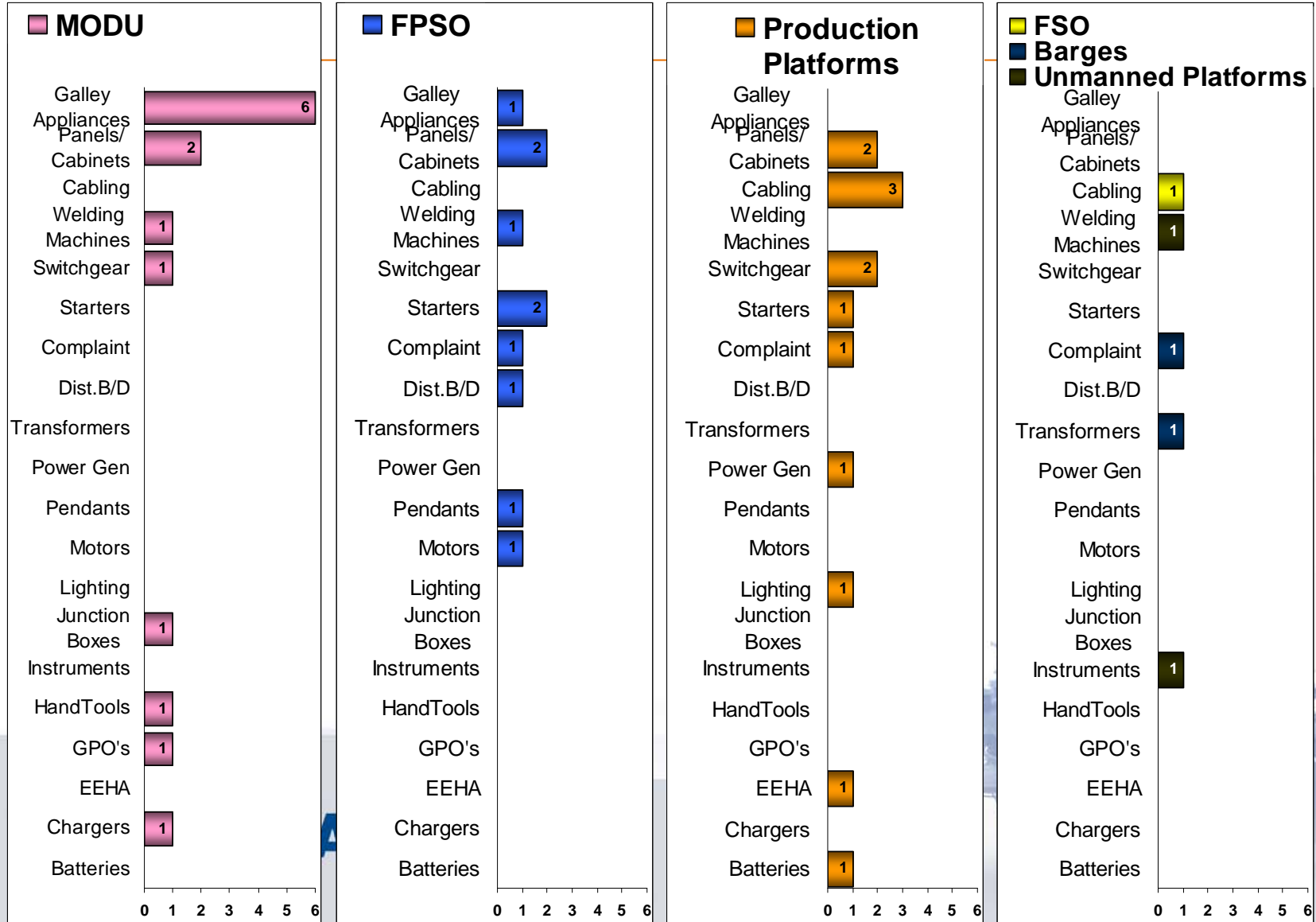


by Fault Mechanisms per Facility type

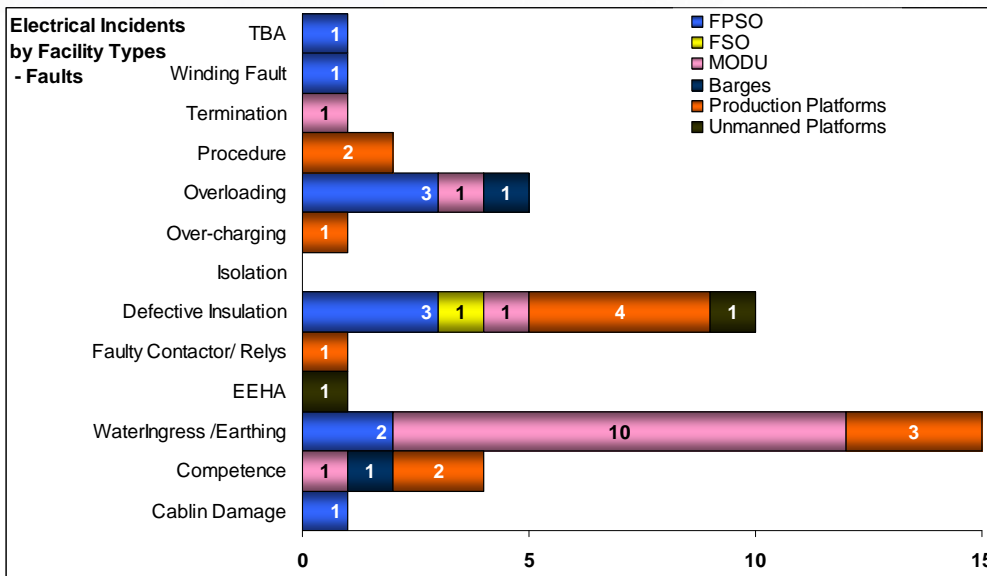


Electrical Incidents

by Facility Type and Equipment

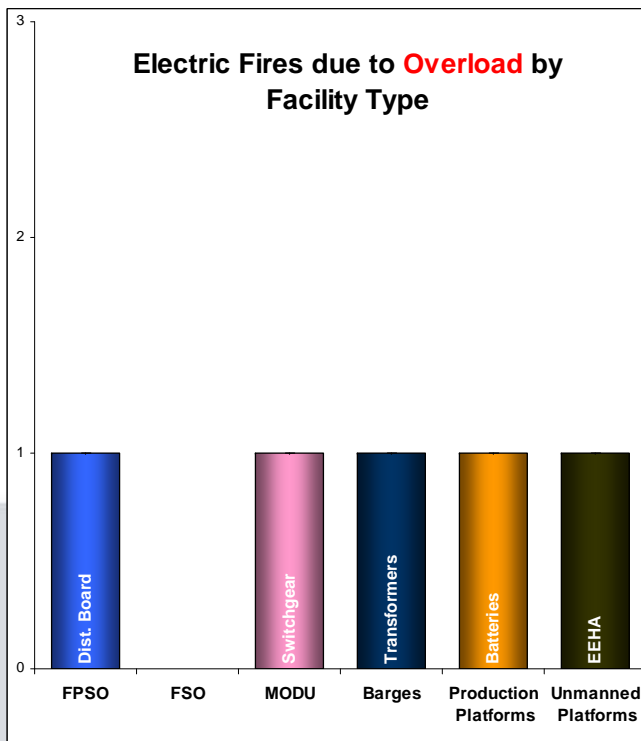


Electrical Incidents



Fault Types

All incidents are attributed to faulty equipment with specific set of faults. 9/42 Incidents due to equipment damage that led to no shock or fire



Overload



Electrical Incidents

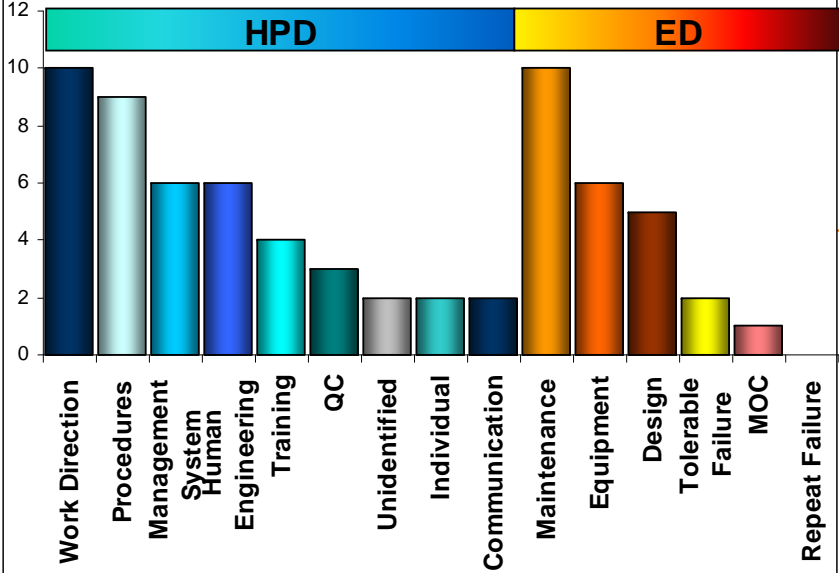
Root Cause Analysis

Root Causes



Electrical Incidents

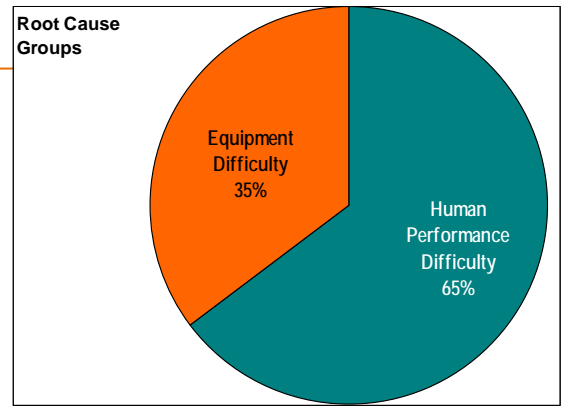
Root Causes



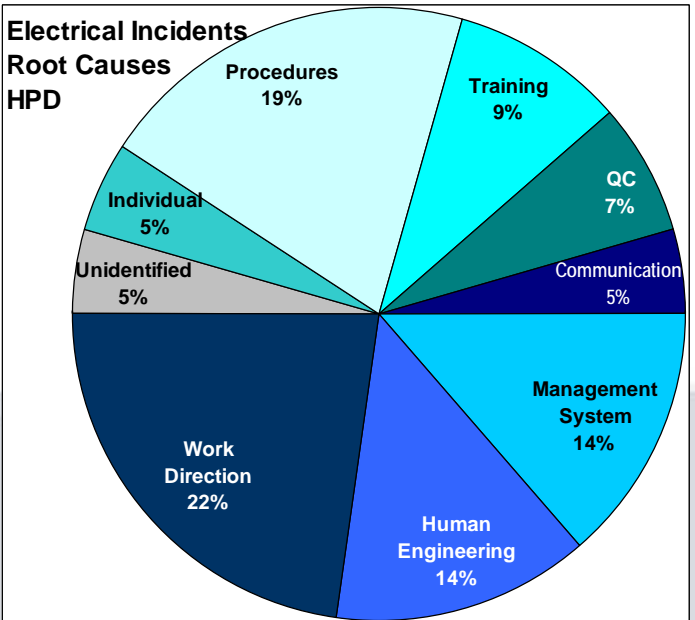
Electrical Incidents

by TapRoot Root Cause Groups

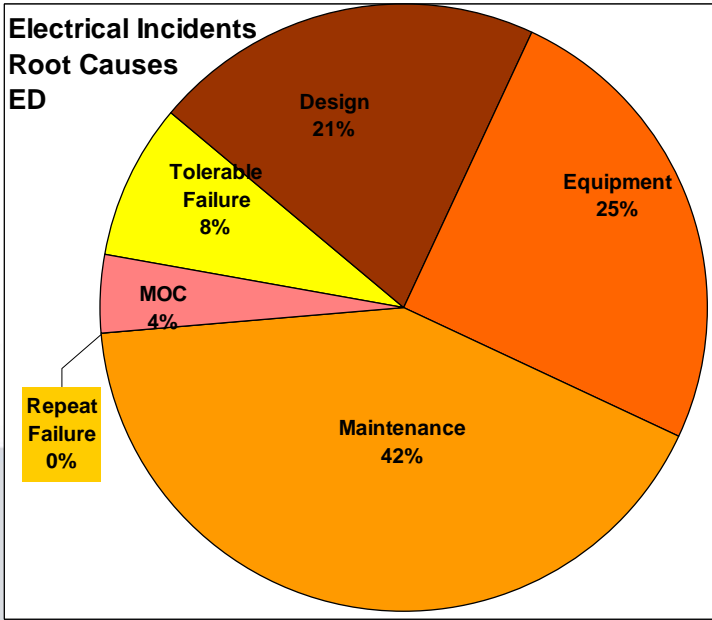
Overall Split



Human Performance Difficulties



Equipment Difficulties



Areas of concern in each group

Conclusions

- **Electrical Incidents 4% of all reported incidents, of which**
 - 60% Electric Shock Incidents – Galley Equipment by earthing
 - 21% Electric Faults - Insulation
 - 12% Electric Fires – Overload and EEHA
 - 7% Miscellaneous and Complaints - competency
- **Electrical Incident distribution amongst facilities**
 - 33% in Production Platforms - Electric Enclosures and cabling
 - 31% in MODU's – Galley Equipment and Electric Enclosures
 - 24% in FPSO's – motor starters and distribution boards
 - 12% in FSOs, Barges and NUI's - various

Conclusions

..cont'd

Distribution of Electrical Incidents	Electric Shocks	Electric Faults	Electric Fires	Complaints
FPSO	20%	44%	20%	0%
FSO	4%	0%	0%	0%
MODU	52%	0%	20%	0%
Barges	0%	0%	20%	33%
Production Platforms	20%	56%	20%	67%
Unmanned Platforms	4%	0%	20%	0%

End of Presentation

(Appendix attached)



Residual Current Device (RCD)

- Also called residual current circuit breaker (RCCB)
- An electrical wiring device that disconnects a circuit whenever it detects that the flow of current is not balanced between the phase (“live” or “hot”) conductor and the neutral conductor
 - e.g. caused by current leakage through the body of a person who is grounded and accidentally touching the energised part of the circuit.
- A lethal shock can result from these conditions.
- Designed to disconnect quickly enough to mitigate the harm caused by such shocks.
- In US/Canada also known as a ground fault circuit interrupter (GFCI), Ground Fault Interrupter (GFI) or an appliance leakage current interrupter (ALCI).
- National Electrical Code, requires GFCI devices (intended to protect people) to interrupt the circuit if the leakage current exceeds a range of 4–6 mA within 25 milliseconds (exact trip setting chosen by manufacturer = typically 5 mA).
- GFCI devices which protect equipment (not people) are allowed to trip as high as 30 mA of current. In Europe, commonly used RCDs have trip currents of 10–300 mA.

Overloads

- over-current detection provides protection for faults which do not involve an external leakage current
 - e.g. faults that pass the current directly from one side of the circuit through the victim to the other.
- Notably, RCDs do not provide protection against overloads or short circuits between phase (live/hot/line) and neutral or phase to phase.



Residual Current Circuit Breaker with Overcurrent Protection (RCBO)

- Combined RCD+circuit breaker units combine the functions of an RCD with those of a conventional circuit breaker, responding appropriately to fault currents and overload conditions.
- RCBOs will typically have separate circuits; with common devices for interrupting the flow of current.
 - i. for detecting current imbalance (RCD function)
 - ii. for detecting overload current (circuit breaker function);
- An RCD+circuit breaker can individually improve the safety of an electrical system but cannot remove all risk of electric shock or fire.
- An RCD will protect against phase to earth faults, it does not detect overload conditions
 - e.g. phase to neutral (Ph-N) or phase-to-phase (Ph-Ph) short circuits.
- An over-current protection (fuse or circuit breaker) must be employed to guard against overload conditions
 - e.g. Ph-N or Ph-Ph short circuits

Ventricular Fibrillation

- Ventricular fibrillation is a very rapid, uncoordinated, ineffective series of contractions throughout the lower chambers of the heart.
- Unless stopped, these chaotic impulses are fatal.
- When the ventricles begin to quiver, and do not employ coordinated contractions, the heart is said to be fibrillating.
- In this condition the ventricles cannot pump blood from the heart.
- Ventricular fibrillation (V-fib) is the worst kind of abnormal heart rhythm, and is a form of cardiac arrest.
- In comparison, atrial fibrillation involves upper chambers of the heart.