INDUSTRIAL ACCIDENT INVESTIGATION

SAFETY CASE

Independent Investigation, with Specialist Engineering Assistance

Fatal Electrical Arc-Flash Incident

Low-Voltage Water-Treatment Switchgear

Combined-Cycle Gas Turbine Power Plant (Under Commissioning)

Subject of report	Fatal arc-flash incident, low-voltage (LV) water-treatment switchgear
Nature of injury	Burns to more than 90% of body surface; inhalation injury; death 10 days after injury
Standards engaged	IEC 61439-1; IEC / EN 61111; applicable PPE standards
Report type	Independent industrial accident investigation / safety case
Prepared by	Industrial Accident Investigator (lead), assisted by a consulting expert engineer
Status	Prepared on the basis of evidence supplied; inferences identified as such
Confidentiality	Private & Confidential — for investigation, root-cause determination and remedial action

Anonymisation note: All personal names, nationalities, company and brand names, project names, specific ratings and identifying reference numbers have been removed and replaced with generic role and organisational descriptors. The parties are referred to by function only — for example the Project Management Team (PMT), the EPC Contractor, the Sub-contractor (employer of the deceased), the Equipment Supplier, and the individuals by their job roles.

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1. Investigator's Declaration & Scope

1.1 Basis of Instruction

I was appointed as Industrial Accident Investigator to conduct an independent investigation into a fatal electrical arc-flash incident at a combined-cycle gas turbine power plant then undergoing commissioning. The deceased, a young electrical and instrumentation engineer in his late twenties, sustained burns to more than ninety per cent of his body and died of his injuries ten days later.

In conducting this investigation I was assisted by a consulting expert engineer, retained to examine the technical and engineering aspects of the asset, its compliance with the applicable standards, and the electrical mechanism of the event. The engineering findings reported in Section 6, and the engineering opinions identified as such elsewhere in this report, were formed with that assistance; the investigation, its conduct, and the overall findings and conclusions are my own.

This safety case sets out the facts as established from the evidence supplied, the engineering and procedural failures identified, an analysis of causation, and the conclusions reached as to the root cause and contributing factors. It concludes with a corrective action plan addressed to each accountable party.

1.2 Scope of the Investigation

The investigation addressed the following matters:

- The design, manufacture and installation of the water-treatment LV switchgear and its compliance with applicable standards.
- The fault state of the asset and whether an electrical defect initiated the event.
- The system of work, permit-to-work (PTW) controls and supervision in force at the time.
- The competence, authorisation and instruction of the deceased.
- The personal protective equipment (PPE) and tools available and used.
- The quality-assurance and turnover regime governing energisation and commissioning.
- The management culture and oversight of the Project Management Team (PMT), the EPC Contractor and the Sub-contractor.

1.3 Material Examined

This investigation is founded on the physical evidence recovered from the scene, photographic records of the switchgear and the damaged equipment, the post-incident electrical testing of the motor and cable, the permit and risk-assessment documentation, witness statements taken by the EPC HSE team, and interviews conducted with members of the PMT, the EPC Contractor and the Sub-contractor management. The physical examination and testing of the switchgear and the assessment of its compliance were carried out with the assistance of the consulting expert engineer.

Caveat on the evidence. *Witness statements were taken by the EPC HSE team rather than an independent party, and by the time of the independent investigation none of the witnesses remained available on the project. Documentary copies could not be re-verified at source. Where I have drawn an inference rather than a direct finding, I have said so. One element of the sequence — the precise mechanism by which the cover plate reached the busbars — is an inference based on experience of similar events and is identified as such.*

2. Executive Summary

During commissioning of a water-treatment plant, a young electrical and instrumentation engineer attempted live fault-finding on an energised LV switchgear panel after a feed pump failed to transition from star to delta during start-up. He removed the front plate of the instrumentation-and-control (I&C) box using a 240-volt test screwdriver. The detached metal cover plate is understood to have slipped from a fixing bar onto unsleeved, exposed busbars, initiating a phase-to-phase arc flash that engulfed him in flames.

The fire was extinguished by a security guard using carbon-dioxide and dry-powder extinguishers. The engineer received burns to more than 90% of his body together with inhalation injury and died ten days later.

2.1 Principal Conclusion

Root cause. *A young engineer was directed to fault-find on live LV switchgear that should never have been accessible — and the entire chain of controls intended to prevent that had already collapsed. The underlying root cause was a production-over-safety culture, with absentee oversight by the Project Management and EPC teams and unenforced procedures, sitting beneath a defective, non-compliant asset.*

2.2 Summary of Findings

Domain	Key finding
Asset / Design	Busbars left bare and unsleeved; internal partition fitted inverted, exposing live busbars in the cable alley; panel reverts to IP00 when doors open.
Electrical fault	Motor and cable tested healthy post-incident — an electrical fault is a highly unlikely cause.
Permit to work	PTW covered mechanical work only; did not authorise electrical work or work in the switchroom; dated for 7 days against an 8–12 hr plan limit.
Competence	Deceased was instrumentation-biased with no demonstrated electrical competence and no training record for the panel.
PPE & tools	No arc-flash suits or insulating gloves in stock; substandard PPE; matting below IEC 61111; a 240V tester used on LV switchgear.
Quality assurance	Nine QA/QC hold points signed off without inspection; turnover package approved as a desktop exercise.
Supervision	Work performed during the EPC lunch break, unsupervised; PMT offices ~100 m from site; HSE presence minimal.

3. Background & Context

3.1 The Project

The facility is an independent power plant (IPP): a green-field, integrated combined-cycle gas turbine power plant. At the time of the incident the project was under commissioning, with commercial operation expected shortly afterwards. The plant was a large multi-unit installation comprising several gas turbines, steam turbines, heat-recovery steam generators and cooling towers, fired primarily on natural gas with liquid fuel as back-up.

The water-treatment plant package had been assigned by the main EPC Contractor to a specialist water-equipment Sub-contractor, which was responsible for the demineralisation (Demin) plant equipment, electrical panels, PLC and drives. At the time of the incident the Demin plant was in the final stage of commissioning, and most of the Sub-contractor's workforce had been demobilised.

3.2 The Electrical Arrangement

Construction power was drawn from the local network. The medium-voltage unit-service switchgear fed the common switchgear, which in turn supplied the water-treatment plant switchgear via a step-down transformer. The water-treatment LV switchgear had two incomers and, at the time of the incident, was energised from one incomer, with all feeders in the racked-in (withdrawable) position.

3.3 The Equipment

The water-treatment switchgear was supplied by a control-technology firm and built by a third-party panel integrator from bought-out components. The cabinets were delivered as flat-pack units and assembled on site. As discussed in Section 6, the on-site assembly was a critical point at which a construction defect was introduced and never caught.

3.4 The Deceased

Age / role	A young engineer in his late twenties; Electrical & Instrumentation Engineer employed by the Sub-contractor
Qualification	Bachelor's degree (technology), with approximately four years' experience
Experience profile	Predominantly PLC and instrumentation systems; no demonstrated hands-on electrical-systems competence
Relevant training	Commissioning safety induction; permit-receiver training

4. Sequence of Events

The following narrative is reconstructed from witness statements and the physical evidence. The mechanism of arc initiation is, as noted, an inference based on experience of similar incidents. All persons are referred to by role only.

Time	Event
Day before, ~09:00	A general PTW was obtained by the Sub-contractor for commissioning of the motors, valid for several days. The no-load trial run had been reported completed successfully via local push-button operation.
Incident day, ~11:55	The deceased and a colleague were assigned to conduct the load trial run of a feed-pump stream. The deceased signed the switchroom entry log maintained by the security guard at the door.
~12:00	Work commenced during the EPC lunch break, with no EPC supervision present. The deceased was at the switchgear; the colleague was at the pump.
—	The deceased started the pump from the PLC; the motor tripped after initial run-up. He told the colleague by radio that he would rectify the fault in ten minutes.
—	He opened the cable alley and removed the front plate of the I&C LV box using a 240V test screwdriver — the maximum-rated tool available to him.
—	It is inferred that the cover plate was set on a cabinet fixing bar to his right, slipped off, struck the cables below and came to rest on the exposed busbars.
—	A phase-to-phase arc flash occurred. The deceased was engulfed in flames.
—	The security guard at the entrance extinguished the flames using carbon-dioxide and dry-powder extinguishers, and alerted his supervisor, who informed the EPC HSE coordinator.
—	A site nurse gave first aid; the deceased was taken to a local government hospital.
10 days later	The deceased succumbed to his injuries and died.

5. Nature of the Injuries

The medical findings are material to the severity of the hazard and to the inadequacy of the protective measures. Burns are conventionally classified as first-degree (superficial), second-degree (partial thickness) and third-degree (full thickness).

Injury	Extent / description
Total burn area	More than 90% of total body surface
Partial-thickness burns	Approximately 60% of body surface
Full-thickness burns	More than 30% of body surface
Inhalation injury	Third-degree airway burns; lung damage from flame inhalation
Other acute trauma	Acute trauma to the larynx, trachea and bronchi; further acute trauma noted

Engineering significance of the injury pattern. *The combination of extensive partial- and full-thickness burns with severe inhalation injury is consistent with direct engulfment in an arc-flash fireball at close range, without arc-rated protection. The presence of inhalation burns indicates the casualty was within the immediate plasma/flame envelope. Appropriate arc-flash PPE and an enforced minimum approach boundary would have materially altered this outcome.*

6. Technical & Engineering Findings

6.1 Installation of the Asset

- The switchgear installation was carried out by the panel supplier.
- Busbar-to-panel clearances were found to differ on the two sides of the panel.
- Control and instrumentation cables were found running directly over the busbars within the panel.
- Cable gland holes were found not sealed.
- Loose hardware was found resting on the busbars and inside the panels.
- The partition cover of one vertical section was installed incorrectly, exposing the live busbar in the cable alley.

6.2 Fault State of the Asset

The switchgear was energised before the incident. Post-incident testing of the motor and its connecting cable revealed no phase-to-ground fault; both were found healthy. On the facts collected, no electrical fault was present that would have caused the arc flash. On the engineering assessment, an electrical fault is a highly unlikely cause of the event — the initiating mechanism was mechanical (the cover plate contacting exposed live busbars).

6.3 Design of the Asset

Several design and configuration features placed the asset outside the relevant standard:

- The LV switchgear had bare busbars and busbar droppers that were not sleeved; the specification required sleeving.
- Doors were secured with hinges and latches; access to bus compartments should require correct tools, and shields should be provided — neither condition was met.
- Once the doors were opened, the panel reverted to IP00 (no protection against contact with live parts).
- The significance of metallic cable-termination boxes within the cable alley could not be established.

Standard engaged — IEC 61439-1, §8.4.2.2. *The switchgear was found in a state not fully complying with IEC 61439-1, §8.4.2.2, which requires (in substance) that hazardous live parts be completely covered with insulation removable only by destruction or by use of a tool, the insulation being of materials capable of durably withstanding the mechanical, electrical and thermal stresses to which it may be subjected in service.*

6.4 Specification & Conceptualisation

Comparison of the two switchgears in the same room indicated that the switchgear specification was generic in nature. The specification itself was not evaluated as part of this investigation, and I express no opinion on its adequacy beyond noting its generic character.

6.5 Quality Assurance & Turnover

The cabinets were delivered flat-packed and assembled on site, yet no quality checks were undertaken during construction. Approximately nine inspection hold points should have been completed between construction and turnover:

- QA/QC inspection of cabinet construction — Sub-contractor
- QA/QC inspection of cabinet construction — EPC Contractor
- QA/QC inspection of cabinet construction — PMT
- Installation of electrical components — QA/QC inspection
- Pre-energisation QA/QC inspection
- Energisation QA/QC inspection
- Pre-commissioning QA/QC inspection
- Commissioning QA/QC inspection
- Turnover package QA/QC inspection

The EPC Contractor and the PMT each signed off QA/QC acceptance with no inspection. The PMT quality manager stated in interview that he rarely inspected physically and relied on EPC-provided information. The turnover-package manager admitted that he never visited site, that sign-off was a desktop exercise, and that he generally read only the cover sheet before stamping; he subsequently resigned.

Critical causal link. *Had any one of the quality, pre-energisation, energisation, commissioning or turnover inspections been carried out, the incorrectly constructed internal cabinet wall — which left the busbars exposed — would have been identified early. The internal wall should have been fixed from bottom to top, leaving a gap at the top, not the bottom. A single working inspection at any of nine hold points would most likely have caught the defect that killed the engineer.*

7. Procedural & Human-Factors Findings

7.1 Permit to Work

- The Sub-contractor obtained a PTW dated the day before the incident, valid for several days.
- The activities specified did not state work on a live system, and the water-treatment switchgear was nowhere mentioned — the permit was for mechanical works only.
- The work was performed around midday, within the EPC lunch break, suggesting it proceeded without supervision by the principal EPC Contractor.
- The deceased was not authorised to work on a live electrical system without a valid PTW.

The investigation concludes that the work that led to the death was carried out without a valid permit to work for the activity actually undertaken.

7.2 Instruments & Tools

The deceased was carrying out electrical fault-finding with a maximum 240V line tester (a tester-screwdriver) on LV switchgear following the pump trip. The use of a 240V line tester for this purpose is neither acceptable nor good practice in industry and provides no protection against the energy present in the switchgear.

7.3 Work Competencies

The deceased was designated by the Sub-contractor for Demin plant commissioning across both instrumentation and electrical systems. A review of his record showed work predominantly on PLC and instrumentation systems, with no suitable hands-on electrical experience evident. There was no evidence that he had been trained to work on the panel concerned, or on the other panels for which he was made responsible.

7.4 Personal Protective Equipment

- The deceased was not wearing suitable PPE; the general PPE was of poor quality and substandard.
- There was no evidence that the EPC Contractor or Sub-contractor held arc-flash suits in their PPE stock.
- There was no evidence of insulating gloves in either party's PPE stock.
- Rubber matting was present but did not meet IEC / EN 61111; it was supplied by an unverified manufacturer.
- EPC and Sub-contractor PPE did not conform to the applicable standards.

7.5 Commissioning Safety Management

- Commissioning safety procedures were of unacceptable quality.
- Commissioning risk assessments were generic and effectively identical to the generic construction risk assessment.
- Method statements were poor, with essential information missing.
- Commissioning areas were not adequately identified, and access control was not effectively managed.
- An uncontrolled switchgear-panel door key was held by the deceased, who was not authorised to hold it.

- No PTW audits were carried out by either the EPC Contractor or the PMT.
- There was no task-specific risk assessment for the activity that resulted in the death.
- The commissioning safety induction was poor and delivered by a safety officer with no commissioning-safety experience.

7.6 Management Culture & Oversight

The investigation disclosed a pervasive production-over-safety culture and a pattern of absentee oversight:

- No evidence of a toolbox talk by the Sub-contractor.
- PMT offices were located approximately 100 m from site; the team was described as complacent and not visible on site.
- The EPC HSE manager admitted visiting site only a few times per week, generally outside active periods, citing workload and language barriers between the workforce groups.
- The EPC deputy HSE manager also served as deputy construction manager — a conflict of role.
- Operatives routinely worked in excess of 16 hours per day.
- Most work activities were left under Sub-contractor supervision.

Note on management attitude. *Interview evidence indicated a complacent leadership tone from the top. By way of illustration of the attitude encountered (the original statement being unusable for legal reasons), one senior manager recounted that, as an apprentice, the practice had been to wet a finger and briefly touch a cable to check whether it was energised. A construction manager admitted he had not wished to be on the project and rarely visited site. The investigation regards such attitudes as indicative of the cultural conditions in which this fatality became possible.*

8. Root-Cause Analysis

8.1 Analytical Method

I have combined a bow-tie sequencing of the event with a Five-Whys drill-down to root level, cross-checked against a fishbone (man / machine / method / management) analysis to ensure no causal branch was overlooked. Each barrier in the bow-tie represents a defence that should have arrested the sequence; every one had already failed before the engineer touched the panel.

8.2 The Barrier Sequence (Bow-Tie)

Stage	Description
Hazard	Energised, unsleeved busbars exposed in the cable alley.
Task	Live fault-finding on LV switchgear with a 240V test screwdriver.
Trigger	Metal cover plate set on a fixing bar slips onto the exposed busbars.
Event	Phase-to-phase arc flash — engineer engulfed.
Outcome	Burns to 90%+ of body; fatality after 10 days.

8.3 The Five Whys

#	Question	Answer
1	Why did the engineer die?	An arc flash engulfed him in flames, causing 90%+ burns and inhalation injury.
2	Why did the arc flash occur?	A metal cover plate slipped onto live, exposed busbars inside the panel.
3	Why were live busbars exposed and reachable?	The internal partition was fitted incorrectly, and busbars were unsleeved — and he was doing live work with the doors open.
4	Why was the defect never caught, and live work allowed?	Nine QA/QC inspections were signed off without inspection; no valid electrical PTW, risk assessment or supervision controlled the task.
5	Why did the management system permit all of this?	A production-over-safety culture with absentee PMT/EPC oversight and unenforced procedures — the true root cause.

8.4 Statement of Root Cause

Opinion as to root cause. *A young engineer was directed to fault-find on live LV switchgear that should never have been accessible — and the entire chain of controls meant to prevent that had collapsed. The unsafe condition: live busbars left exposed in the cable alley — internal partition fitted inverted, busbars unsleeved, contrary to IEC 61439-1 §8.4.2.2. The unsafe act: live fault-finding by an unauthorised, instrumentation-biased engineer, under no PTW for electrical work, using a 240V test screwdriver and no arc PPE. Why it reached him: nine QA/QC hold points signed off without inspection; no task risk assessment, no supervision, no lock-out/tag-out control — a production-over-safety culture top to bottom.*

9. Contributing Factors

The factors below, grouped by category, each removed or weakened a defence. No single factor caused the death; their accumulation did.

Equipment / Design

- Busbars bare, not sleeved — against specification.
- Internal partition cover installed inverted.
- Panel becomes IP00 once doors are opened, no shields.
- C&I cables run across busbars; glands unsealed.
- Loose hardware found resting on busbars.

Permit / Procedure

- PTW covered mechanical work only — not the switchroom or electrical work.
- Permit dated for 7 days against an 8–12 hr plan limit.
- No task-specific risk assessment (RAMS generic).
- No PTW audits by EPC or PMT.
- Uncontrolled panel door key held by the deceased.

People / Supervision

- Engineer competent in I&C, not electrical.
- No training record for the panel.
- Work done in the lunch break, unsupervised.
- 16+ hour days; production-driven culture.
- QA/QC sign-offs with no inspection (turnover desktop only).

Protection / Response

- No arc-flash suit or insulating gloves in stock.
- PPE substandard, non-conforming to applicable standards.
- Rubber matting below IEC 61111 class.
- 240V tester used on LV switchgear.
- Only fire extinguishers available at the scene.

10. System Failures by Accountable Party

Party	Where the layer failed
Project Management Team	Absentee oversight (offices ~100 m away); QA/QC and turnover packages signed off as desktop exercises; no PTW audits; complacent leadership tone.
EPC Management Team	Permit system not enforced; HSE manager on site only a few times a week; language barrier left sub-contractors effectively unsupervised; production culture.
Sub-contractor (water package)	Incorrect panel build and installation; no toolbox talk; tasked an I&C engineer with electrical work he was neither trained nor authorised for.
Equipment / Supplier	Switchgear delivered non-compliant with IEC 61439-1 — unsleeved busbars, IP00 when open, no bus-compartment shields.
Individual	Undertook live fault-finding without authority, valid PTW, correct tools or PPE — though enabled and directed by all the failures above.

Apportionment note. *Although the immediate unsafe act was the deceased's, the investigation finds that individual culpability is heavily mitigated. He was a young engineer, assigned a task outside his competence, without authority, supervision, correct tools or protective equipment, on a defective asset that should never have presented exposed live parts. The dominant failures lie with the management, quality and supply systems above him.*

11. Corrective Action Plan

The following actions are recommended, addressed jointly to the Project Management Team, the EPC Management Team and the Sub-contractor Management Team. Timeframes run from the date of acceptance of this report.

11.1 Immediate (24–72 hours)

- Stop all live work; isolate and apply lock-out/tag-out (LOTO) to the water-treatment switchgear.
- Quarantine the panel and commission an independent arc-flash hazard survey.
- Suspend all permits and recall every uncontrolled key.

11.2 Short Term (2–6 weeks)

- Re-issue the PTW system and prohibit work during the EPC lunch window.
- Sleeve the busbars and refit the partition; verify the asset against IEC 61439-1.
- Re-verify competence of all commissioning personnel; procure arc-flash PPE and matting to IEC 61111.

11.3 Systemic (1–3 months)

- Re-run all nine QA/QC hold points with genuine, witnessed inspection.
- Mandate minimum PMT/EPC site presence and institute a PTW audit regime.
- Reset the commissioning-safety culture and cap working hours.

Horizon	Owner(s)	Primary objective
24–72 hrs	EPC + PMT	Make the asset and the site safe; stop the bleeding.
2–6 weeks	Sub-contractor + EPC	Correct the defective asset and close PPE/competence gaps.
1–3 months	PMT (lead)	Repair the management, quality and culture systems.

12. Conclusion & Findings

The investigation concludes, on the basis of the evidence supplied and supported by the engineering assessment, that this fatality was not the product of misfortune or of a single error. Every barrier that should have protected the engineer — design, permit, competence, supervision, PPE and quality assurance — had already failed. The arc flash was simply the moment at which those accumulated failures met a person.

> **Closing statement.** *A single working control at any layer — a compliant panel, one genuine QA/QC inspection, a valid electrical permit, proper supervision, the correct tools, or arc-rated PPE — would most likely have prevented this fatality. The duty now is to ensure that no future task is allowed to proceed with every defence simultaneously down.*

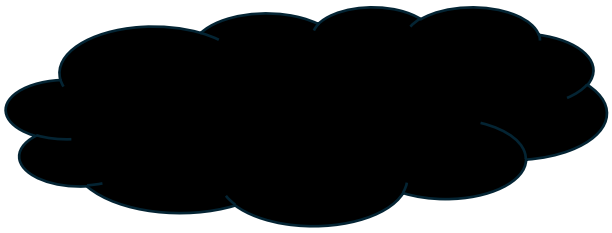
12.1 Statement of the Investigator

I confirm that this investigation was conducted independently and that the findings and conclusions set out in this report are my own. I have endeavoured to be accurate and complete, to set out the substance of all material evidence considered, and to distinguish clearly between fact, established finding and inference. Where the report relies on engineering analysis, that analysis was carried out with the assistance of the consulting expert engineer, whose statement follows.

The consulting expert engineer confirms that the engineering findings and opinions attributed to the engineering assessment in this report represent his true and complete professional opinion on the technical matters to which they refer, formed to a reasonable degree of engineering certainty on the basis of the evidence examined.



Industrial Accident Investigator
Lead Investigator & Author
Date: [redacted]



Consulting Expert Engineer
Specialist Engineering Assistance
Date: [redacted]

End of report. Identities of company, project and individuals have been redacted in accordance with legal obligations. This report has been prepared from evidence supplied and is subject to the caveat at Section 1.3.