Industrial Lighting and Safety

“Can you see the problem?”

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Agenda

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Fatality Case Study 2 (if time permits)
Introduction

• Do we pay enough attention to lighting?
• Is there data to substantiate a closer look?
• Can safety performance be improved by paying attention to lighting?
• We can not run our facilities without lighting!
  – The round-the-clock industrial revolution was enabled by lighting
References

• Much of the data presented in these slides comes from
  – ANSI/IESNA RP-7-01, Recommended Practice for Lighting Industrial Facilities

• Occupational Health & Safety (OH&S) rules quoted are from the Alberta (Canada) code

• The statistical data and incidents are quoted from major petroleum companies operating in Alberta, Canada
Background

- The better the lighting conditions, the more productive we are.

- Relative illumination needed by different age groups to carry out a specific eye-task

<table>
<thead>
<tr>
<th>Age</th>
<th>Seeing Ability</th>
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<tbody>
<tr>
<td>10 Years</td>
<td>1</td>
</tr>
<tr>
<td>20 Years</td>
<td>1.5</td>
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<tr>
<td>30 Years</td>
<td>2</td>
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<td>40 Years</td>
<td>3</td>
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<td>50 Years</td>
<td>6</td>
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<tr>
<td>60 Years</td>
<td>15</td>
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Background

• In 2002, David Berson of Brown University detected a novel third photoreceptor in the retina of mammals which is directly connected to the biological clock of the brain.

• In short and simple terms, application or reduction of light to the eye can switch our bodies on and off.
Background

Illuminance vs Incident Frequency

Good lighting reduces the number of accidents. The percentage of accidents declines significantly as the illuminance in the working environment is increased.
Actual Data - Survey

• Is there a good understanding among workers about what is safe light working conditions?
• Anonymous survey sent to plant technicians
  – 3 major petroleum companies
  – data next page
Actual Data - Survey

Positive Responses

- 30% of electricians aware of incidents related to lighting
- 86% of electricians reluctant to change some lamps due to location
- 83% of electricians feel their facilities lighting is a low priority
- 75% do not understand lighting levels or specs

- 96% feel their facilities lighting is inadequate
Actual Data - Incident Statistics

• A small percentage of overall incidents but suspect **significant** under-reporting

• In the last 3 years, a large petroleum facility has experienced, due to inadequate illumination
  – 2 Lost Time Incidents
  – 5 Medical Aids
  – 28 First Aids
Actual Data - Incident Statistics

• Another company’s 5-year records show that due to slips, trips and falls
  – 18% are Medical Aids
  – 58% of all serious injuries occurred, and
  – A disproportionate number occur at night

Rarely during investigations was poor lighting considered!
Actual Data - Incident Statistics

Incidents by Time of Day

- 1992
- 1993
- 1994
Actual Data - Reporting

• Data is sometimes available through the incident reporting systems.
• Until a better focus and knowledge base is achieved, the data is likely distorted.
• There is a great deal of circumstantial evidence:
  – Work order requests
  – Industrial Hygiene complaints
  – Accidents during night time hours.
Actual Data - Incident Samples

- First Aid - Employee was walking in poorly illuminated area between trailers and slipped on ice resulting in bruised knee.
- First Aid - Employee was descending poorly illuminated steps carrying tools and “caught 1/2 of a step” resulting in a sprained ankle.
- First Aid - Employee was responding to fire alarm, walking down poorly illuminated piperack, when he stepped on an object, tripped and hurt knee.
Illumination Rules

• OH&S Governs Workplace Safety and states, in General Safety Requirements Rule 186.1, that “an employer must ensure that lighting at the work site is sufficient to enable work to be done safely”

• OH&S Refers to the IES (Illumination Engineering Society) for Recommendations for Safe Lighting Levels
Illumination - IES

• IES (ANSI RP 7-01) is the prime reference
• RP 7-01 states that “any factor that aids visual effectiveness increases the probability that a worker will detect the potential cause of an accident”
• Main recommendations for illumination levels, interior and outdoors respectively
Illumination - IES

• Interpretation & Considerations
  – Suggests a minimum of 20 foot-candles on all industrial tasks where there is a sustained seeing requirement
  – 3 Dimensional Viewing (Time, Location, Plane)
  – Uniform lighting levels (low Max / Min ratios)
  – Minimize Glare with appropriate refractors
  – High efficiency / long lasting light sources used in hard to reach areas (Induction Lamps)
Illumination - IES

• Interpretation & Considerations
  – Long term maintenance (considers lamp degradation, environmental factors)

Lamp Degradation

![Graph showing percent of initial lumens versus percent of average rated life with lines for HFS, Metal Halide, and Mercury Vapor]

Cleanliness

![Graph showing percent of initial lumens versus months with lines for Very Clean, Clean, Dirty, and Very Dirty]
Illumination Design

• Lighting specification sources
  – User specifications
  – Manufacturer and engineering company standards, specifications, software
  – Some of these may be weak and/or inconsistent, construction often not audited.

• Not generally a high priority with users
Illumination Design

• Other Considerations
  – Installation details - maintenance friendly?
  – Appropriate controls to ensure lighting is off when not needed (energy consumption, longer lamp life, less maintenance)

• Documentation
  – Often poorly done as cabling is field run
  – Sub-optimal for O&M
Illumination Maintenance

• Group re-lamping programs
  – Help maintain the designed min. lighting levels
  • Therefore improving long term safety (trips, slips, etc.)
  – Better management of waste material containing mercury, lead, arsenic, cadmium

• Lighting controls - higher end microprocessor based solutions available
  – Minimizes lumen degradation over time
  – Also energy savings
Safe Work Practices
Safe Work Practices

Prime Hazards

• Fixtures located at “Inaccessible Locations”
  – Usually elevated, therefore risk of falling
• High percentage of work is “Energized”
  – Difficult to find disconnect device
  – Considered ‘low voltage’ and low risk by many electricians
• Both hazards often occur together making Lighting Work Extremely Hazardous!
Safe Work Practices

Elevated Locations

• Examples
  – Ceilings
  – Stanchion mounts off walkways, platforms
  – Light poles
  – Sides of buildings

• Accessing
  – Ladders, scaffolds
  – Fall protection
    • Worker must be protected by railing
    • Above a specified height, fall protection is required.
Safe Work Practices

Elevated Locations

• Issues
  – Troublesome to get proper equipment for small job
    • Ladders, scaffolds – $$$ and/or time consuming
  – Accessing often involves reaching
  – Appropriate procedures
    • E.g. securing ladders
  – Use of correct equipment
    • E.g. fall arrest, non-conductive ladders
Safe Work Practices

Energized Work

• Considered ‘Low Voltage’
  – However, many voltages >120 V often found
    • E.g. 240, 277, 347, 480, 600 Volt
• Info. (drawings/schedules) identifying the breaker/disconnect often missing or inaccurate
• Disconnect is often inconveniently located
• Troubleshooting often considered easier if done energized
• Energized work considered part of electrician’s job
• “Others in area” want lights on while you fix a light
Safe Work Practices

Other Hazards

• Hazardous Locations
  – Arcing (e.g. wiring work, lamp changing)
  – Hot surfaces
  – “Hot Work” procedures / permits needed

• Lighting considered low priority in Industrial
  – Process and engineered equipment has priority
  – “Hazardous Task Analysis” or “Field Level Risk Assessment” often not conducted
Safe Work Practices

Lighting Case Study - Fatality

• Petroleum Facility, October 1998
• Job: Repair light fixture that was not working
• The Incident
  – Electrician to fix fixture at elevated location
    • Remote ballasted
  – Aluminum ladder to access the fixture
  – Majority of work was performed energized
  – Electrician was startled by an arc or shock
  – Fall resulted in a fatal injury
An Aluminum (conductive) ladder was selected. It was supported by the conduit and tied-off with rope.

The fixture was unhooked from it’s JB, lowered and secured with rope so that the wiring could be accessed.
One wire had become disconnected on the fixture and was pulled into the fixture’s conduit when it was dropped down.

(This is why the fixture was not working)

The wire then contacted the fixture’s conduit.
- The remote ballast was located
- Voltage was measured leaving the ballast
The electrician proceeded to check that voltage was present at the fixture.

Note that the fixture frame is now disconnected from ground, so it will not trip the breaker.
The fixture was swinging loosely, and contacted the ladder, which was leaning on the conduit (arching was found on the ladder)

The electrician was either startled by arcing or received a shock while working on the wiring.

This caused a fall as he was not wearing any fall protection.
He fell through this gap in the platform and a further 6m below, receiving a fatal injury to the head.
Safe Work Practices

Incident Learnings

• Hazardous Task Analysis
  – Identify all hazards - shock, arc, fall
  – Identify all mitigating measures – e.g. PPE, fall arrest, grounding, special procedures
  – Avoid energized work
    • Fixture can be checked on the bench
    • Wire continuity can be checked de-energized

• Use correct equipment
  – Fall arrest
  – Non-conductive ladder
  – Gloves, etc.
Safe Work Practices

Design Improvements

• Easily located disconnects
  – Individual fixture disconnects
  – Plugs / receptacles located near fixtures
  – Switches / disconnect terminals in fixtures
    • Automatic switch disconnects in HazLoc fixtures
• Drawings/Documentation
  – Up-to-date identification of distribution panels
  – Up-to-date identification of lighting circuits in those panels, and at those panels
• Lockable circuits in panels
• Use lower voltage lamps
Safe Work Practices

Design Improvements

• Accessible Locations
  – Several methods available to move the fixture to the worker (rather than worker to the fixture)
    • Winch poles, rotating poles, stanchion mount sliders
  – Use existing walkways / platforms / stairs
    • Mount fixtures so they are easily reachable
Rotating/Swivel Pole
Conclusions and Recommendations

• Incidents
  – Better awareness of lighting as a causal factor
  – Systems which enable identifying lighting factors
  – Recording, tracking and trending data
  – Disseminate learnings
  – Take corrective actions

  – Mobile equipment lighting incidents are higher
    (the data presented was from fixed facilities)
Conclusions and Recommendations

• Design
  – Illumination levels
  – Ensure proper interpretation of standards
    • Maintained minimum levels
    • Consider Glare issues
  – Consider operability and maintenance requirements
  – Lighting obstructions
Conclusions and Recommendations

• Maintenance of Illumination levels
  – Lighting surveys
  – Group re-lamping & controls
  – Consider temporary obstructions
    • E.g. hoardings, scaffolds, etc.

• Safe Work Practices
  – Education
  – Recognition and management of the hazards
    #1 - Avoid Energized work
    Falls, LO/TO, HazLoc, Task Analysis, Tools, etc.
Case Study 2
Case Study 2

• Not originally part of this presentation
• Not Lighting related
• This incident demonstrates why
  – We cannot rely on one barrier to prevent incidents
  – We need to use many barriers, including:
    • Inherent safety
    • Training
    • Work Practices & Procedures
    • PPE

  – **Things Can Go Wrong!**
Case Study 2

• An experienced contract line crew just finished installing a 25 KV cable from an overhead power line to a transformer
  – Safety Std’s existed – contractor was not informed
  – Site Prime Contractor thought Utility was in control
    • I.e. responsibilities (safety/work) were not clear
    • Tailgate meeting held – Line Crew only
    • Numerous communication breakdowns
      ▪ Eng. Contractor, Prime Contractor, Owner, Line Crew, Utility
  – Crew had tapped the 25 KV line energized
    • Verbal approval by the Utility
      – Line Crew and Utility worked together in many areas
    • Owner was not aware of, nor the Prime Contractor
Case Study 2

• Late in the day / long weekend / pressured to finish
• A test was required to verify voltage and phasing
  – A Utility req't. – not an Owner or Eng. Contractor req't.
• The lineman:
  – Had a backhoe operator hold a 750 V meter
  – Put on 17 KV gloves
  – Then tested the 25 KV terminals at the transformer
• The result:
  – Fatal shock to backhoe operator (worked with for 20 yrs.)
  – Shock (step & touch) to observing apprentice
Primary side of 25,000 / 600 v transformer

Primary-side door was open

Secondary-side door (other end) was locked
Amprobe meter and leads - rated for 750 volts
Primary-side fuses and bushings

- Burn mark (from glasses?)
- Burn mark (from watch?)
- Points of contact with leads
Positional Re-Enactment

Worker # 1 - uninjured

Worker # 2 - deceased

Worker # 3 - injured

Worker # 1 - uninjured