Hazards for visual and ocular injuries
Outline

• Occurrence of eye injuries and their prevention
• Mechanical ocular injuries
  • BETT chart vs. Ocular Trauma Score
  • Ocular traumatology: visual and ocular hazards
• Non-mechanical ocular injuries
  • Ocular toxicology: visual and ocular hazards
• Design of eye protection equipment
  • Standards related to eye protection
• Discussion
  • Supplementary reading and learning
  • Mandatory activity no. 4
Bibliography & Links

• Basic:
  
  
  
  
Bibliography & Links

• Complementary:

  • AOO website: American Optometric Association
  
  • INSHT website: INSTITUTO NACIONAL DE SEGURIDAD E HIGIENE EN EL TRABAJO
  
  • OSHA website: UNITED STATES DEPARTMENT OF LABOR
  
  • AENOR website: AENOR
  
  • Journals in Ophthalmology, Optometry, etc.
Lesson 7

Visual Health & Work

- Ergonomics and its link with Occupational Health
  - **First:** to get a safe task
  - **Second:** to fit it at comfortable level
- Senses & Cognition
  - Stress and workload
  - Decision making
- Control & Prevention
  - Safety, accidents and human error
- Engineering anthropometry
  - Biomechanics of work
  - Work physiology
- Work-space design
Visual Health & Work

- Occupational Health: occupational illness vs. accident
Occurrence of eye injuries (I)

• Eye injuries are far more common than believed in Western countries:
  • USA: 685/day, 7 by 1000 people in 2006
  • Spain: 3.6 by 1000 people in 2004, > 50000 people/year

• These injuries are often preventable (< 90 %) if workers take just put your eye protection equipment

• Conditioning work
  • Personal injury ↔ 20% runtime errors
  • Economic damage to the company, public administration ↔ 80% mismanagement
Occurrence of eye injuries (II)

- Statistical data from USA (May, et al. 2000):
  - > 2.5 million eye injuries and 50000 people permanently lose part or all their vision
  - > 45 % of all eye injuries occur in people 18 to 45 years of age
  - > 70 % in males
  - > 40 % happen in the home
  - > 15 % during sports, very common in children age 5 to 14
Occurrence of eye injuries (III)

- Statistical data from Torino-Italia during 2006:

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Number and percentage of injuries according to the place of occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>School</td>
</tr>
<tr>
<td></td>
<td>n (%)</td>
</tr>
<tr>
<td>Adnexal</td>
<td>24 (0.23%)</td>
</tr>
<tr>
<td>Closed</td>
<td>478</td>
</tr>
<tr>
<td>globe</td>
<td>(4.50%)</td>
</tr>
<tr>
<td>Open globe</td>
<td>2 (0.02%)</td>
</tr>
</tbody>
</table>

n = number of injured patients % = percentage on total eye trauma

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Number and percentage of open eye injuries according to the place of occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>School</td>
</tr>
<tr>
<td></td>
<td>n (%)</td>
</tr>
<tr>
<td>Rupture</td>
<td>0</td>
</tr>
<tr>
<td>Penetrating injury</td>
<td>2 (0.02%)</td>
</tr>
<tr>
<td>IOFB</td>
<td>0</td>
</tr>
<tr>
<td>Perforating injury</td>
<td>0</td>
</tr>
</tbody>
</table>

n = number of injured patients % = percentage on total eye trauma

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Percentage and age-corrected incidence according to the site of injury</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0–14 I (%)</td>
</tr>
<tr>
<td>Adnexal</td>
<td>18.1 (0.18%)</td>
</tr>
<tr>
<td>Ipoema</td>
<td>1.9 (0.02%)</td>
</tr>
<tr>
<td>Retinal edema</td>
<td>98 (0.97%)</td>
</tr>
<tr>
<td>Retinal detachment</td>
<td>1.9 (0.02%)</td>
</tr>
<tr>
<td>Conjunctival and corneal abrasion, corneal foreign body</td>
<td>177 (1.75%)</td>
</tr>
<tr>
<td>Rupture</td>
<td>0</td>
</tr>
<tr>
<td>Penetrating</td>
<td>1.9 (0.02%)</td>
</tr>
<tr>
<td>Intra ocular foreign body</td>
<td>0</td>
</tr>
</tbody>
</table>
Occurrence of eye injuries (IV)

• Pediatric eye injuries in USA (2001-2007):

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sample size</th>
<th>National estimates (95% confidence interval)</th>
<th>Percent of emergency department visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnoses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contusion/abrasion</td>
<td>13,186</td>
<td>562,836 (468,035–657,638)</td>
<td>54%</td>
</tr>
<tr>
<td>Foreign body</td>
<td>2,885</td>
<td>161,187 (130,127–192,247)</td>
<td>15%</td>
</tr>
<tr>
<td>Conjunctivitis</td>
<td>1,758</td>
<td>91,203 (68,648–113,758)</td>
<td>9%</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>1,231</td>
<td>43,335 (31,887–54,784)</td>
<td>4%</td>
</tr>
<tr>
<td>Burn</td>
<td>934</td>
<td>54,336 (40,795–67,877)</td>
<td>5%</td>
</tr>
<tr>
<td>Laceration/puncture</td>
<td>679</td>
<td>30,627 (24,038–37,217)</td>
<td>3%</td>
</tr>
<tr>
<td>Hematoma</td>
<td>135</td>
<td>7,568 (5,286–9,851)</td>
<td>1%</td>
</tr>
<tr>
<td>Other&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2,328</td>
<td>97,407 (71,452–123,361)</td>
<td>9%</td>
</tr>
<tr>
<td>Causes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Struck by/against</td>
<td>14,190</td>
<td>593,759 (491,760–695,758)</td>
<td>57%</td>
</tr>
<tr>
<td>Foreign body</td>
<td>3,714</td>
<td>204,510 (166,136–242,885)</td>
<td>20%</td>
</tr>
<tr>
<td>Fire/burn</td>
<td>2,350</td>
<td>124,722 (101,973–147,471)</td>
<td>12%</td>
</tr>
<tr>
<td>Fall</td>
<td>436</td>
<td>15,526 (12,685–18,367)</td>
<td>1%</td>
</tr>
<tr>
<td>Motor vehicle–occupant</td>
<td>330</td>
<td>13,939 (11,099–16,870)</td>
<td>1%</td>
</tr>
<tr>
<td>Cut/pierce</td>
<td>312</td>
<td>12,899 (9,038–16,759)</td>
<td>1%</td>
</tr>
<tr>
<td>Other bite/sting</td>
<td>235</td>
<td>9,344 (6,231–12,456)</td>
<td>1%</td>
</tr>
</tbody>
</table>
Lesson 7

Occurrence of eye injuries (V)

- Eye injuries in the elderly from consumer products in USA (2001-2007):

### Table 4: Consumer products; leading causes of eye injuries

<table>
<thead>
<tr>
<th>Consumer product</th>
<th>Sample Size</th>
<th>% of ED visits</th>
<th>National estimates</th>
<th>n (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</td>
<td>322</td>
<td>22%</td>
<td>15,236</td>
<td>(13,482, 16,989)</td>
</tr>
<tr>
<td>Cutting tools/construction</td>
<td>277</td>
<td>21%</td>
<td>14,524</td>
<td>(12,777, 16,272)</td>
</tr>
<tr>
<td>Furniture</td>
<td>252</td>
<td>15%</td>
<td>10,145</td>
<td>(8,724, 11,566)</td>
</tr>
<tr>
<td>Gardening</td>
<td>188</td>
<td>14%</td>
<td>9,467</td>
<td>(8,021, 10,912)</td>
</tr>
<tr>
<td>Household items</td>
<td>126</td>
<td>7%</td>
<td>5,022</td>
<td>(4,004, 6,040)</td>
</tr>
<tr>
<td>Appliances</td>
<td>65</td>
<td>4%</td>
<td>3,081</td>
<td>(2,226, 3,936)</td>
</tr>
<tr>
<td>Household tools</td>
<td>51</td>
<td>3%</td>
<td>2,331</td>
<td>(1,591, 3,070)</td>
</tr>
<tr>
<td>Sports equipment</td>
<td>49</td>
<td>3%</td>
<td>2,276</td>
<td>(1,559, 2,993)</td>
</tr>
<tr>
<td>Office supplies</td>
<td>36</td>
<td>3%</td>
<td>1,570</td>
<td>(968, 2,173)</td>
</tr>
<tr>
<td>Glasses</td>
<td>34</td>
<td>2%</td>
<td>1,379</td>
<td>(830, 1,929)</td>
</tr>
<tr>
<td>Vehicles</td>
<td>13</td>
<td>1%</td>
<td>806</td>
<td>(343, 1,270)</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>42</td>
<td>3%</td>
<td>2,027</td>
<td>(1,337, 2,716)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,455</strong></td>
<td><strong>100%</strong></td>
<td><strong>67,864</strong></td>
<td><strong>(65,850, 69,878)</strong></td>
</tr>
</tbody>
</table>

*Number of eye injury cases caused by listed consumer product

**Emergency department

*Weighted frequencies projected by CPSC-NEISS

### Table 5: Leading diagnoses of eye injuries

<table>
<thead>
<tr>
<th>Diagnoses</th>
<th>Sample size</th>
<th>% of ED visits</th>
<th>National estimates</th>
<th>n (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contusion/abrasion</td>
<td>588</td>
<td>39.7%</td>
<td>26,968</td>
<td>(24,850, 29,086)</td>
</tr>
<tr>
<td>Foreign body</td>
<td>248</td>
<td>18.5%</td>
<td>12,586</td>
<td>(10,952, 14,220)</td>
</tr>
<tr>
<td>Conjunctivitis</td>
<td>160</td>
<td>11.4%</td>
<td>7,765</td>
<td>(6,439, 9,091)</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>106</td>
<td>7.0%</td>
<td>4,745</td>
<td>(3,731, 5,579)</td>
</tr>
<tr>
<td>Burn</td>
<td>76</td>
<td>6.0%</td>
<td>4,045</td>
<td>(3,056, 5,034)</td>
</tr>
<tr>
<td>Laceration/puncture</td>
<td>57</td>
<td>3.3%</td>
<td>2,262</td>
<td>(1,560, 2,963)</td>
</tr>
<tr>
<td>Hematoma</td>
<td>38</td>
<td>2.6%</td>
<td>1,792</td>
<td>(1,144, 2,441)</td>
</tr>
<tr>
<td>Other</td>
<td>182</td>
<td>12.3%</td>
<td>8,347</td>
<td>(7,012, 9,682)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,455</strong></td>
<td><strong>100%</strong></td>
<td><strong>67,864</strong></td>
<td><strong>(65,850, 69,878)</strong></td>
</tr>
</tbody>
</table>

*Actual number of injuries reported by CPSC-NEISS

**Emergency department

*Weighted frequencies projected by CPSC-NEISS
Occurrence of eye injuries (VI)

- Sports-related eye injuries in USA (2001-2009):

<table>
<thead>
<tr>
<th>Sports</th>
<th>Injury rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>0.64</td>
</tr>
<tr>
<td>High risk</td>
<td>1.51</td>
</tr>
<tr>
<td>BB and paintball</td>
<td>2.92</td>
</tr>
<tr>
<td>Basketball</td>
<td>2.16</td>
</tr>
<tr>
<td>Baseball</td>
<td>1.62</td>
</tr>
<tr>
<td>Softball</td>
<td>0.67</td>
</tr>
<tr>
<td>Ice hockey</td>
<td>0.15</td>
</tr>
<tr>
<td>Moderate risk</td>
<td>0.80</td>
</tr>
<tr>
<td>Tennis</td>
<td>0.77</td>
</tr>
<tr>
<td>Soccer</td>
<td>1.09</td>
</tr>
<tr>
<td>Volleyball</td>
<td>0.28</td>
</tr>
<tr>
<td>Football</td>
<td>2.16</td>
</tr>
<tr>
<td>Fishing</td>
<td>0.19</td>
</tr>
<tr>
<td>Golf</td>
<td>0.33</td>
</tr>
<tr>
<td>Low risk</td>
<td>0.22</td>
</tr>
<tr>
<td>Swimming</td>
<td>0.35</td>
</tr>
<tr>
<td>Snow skiing</td>
<td>0.14</td>
</tr>
<tr>
<td>Water skiing</td>
<td>0.070</td>
</tr>
<tr>
<td>Bicycle</td>
<td>0.40</td>
</tr>
<tr>
<td>Snowboarding</td>
<td>0.13</td>
</tr>
<tr>
<td>Eye safe</td>
<td>0.045</td>
</tr>
<tr>
<td>Exercise (jogging, running, walking, aerobics)</td>
<td>0.045</td>
</tr>
</tbody>
</table>
Occurrence of eye injuries (VII)

- Epidemiology of ocular chemical burn injuries in USA:

<table>
<thead>
<tr>
<th>Chemical substance</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acids (not further specified)</td>
<td>[28, 30, 35]</td>
</tr>
<tr>
<td>Alkalai (not further specified)</td>
<td>[23, 30]</td>
</tr>
<tr>
<td>Aluminum hydroxide</td>
<td>[30]</td>
</tr>
<tr>
<td>Ammonia</td>
<td>[22, 27]</td>
</tr>
<tr>
<td>Ammonium hydroxide</td>
<td>[30]</td>
</tr>
<tr>
<td>“Black liquor” (a heated mixture of sodium carbonate, sodium hydroxide, sodium thiosulfate, and sodium sulfate)</td>
<td>[34]</td>
</tr>
<tr>
<td>Calcium hydroxide</td>
<td>[30]</td>
</tr>
<tr>
<td>Chili powder</td>
<td>[30]</td>
</tr>
<tr>
<td>Corrosive substances</td>
<td>[18]</td>
</tr>
<tr>
<td>Cracker powder</td>
<td>[30]</td>
</tr>
<tr>
<td>Endoxan injection</td>
<td>[30]</td>
</tr>
<tr>
<td>Fish bile</td>
<td>[6]</td>
</tr>
<tr>
<td>Hydrochloric acid</td>
<td>[30]</td>
</tr>
<tr>
<td>Hydrofluoric acid</td>
<td>[30, 33]</td>
</tr>
<tr>
<td>Kerosene oil</td>
<td>[30]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lost work days</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day</td>
<td>28.8%</td>
</tr>
<tr>
<td>2 days</td>
<td>19.0%</td>
</tr>
<tr>
<td>3–5 days</td>
<td>24.7%</td>
</tr>
<tr>
<td>4–20 days</td>
<td>7.6%</td>
</tr>
<tr>
<td>21–30 days</td>
<td>2.4%</td>
</tr>
<tr>
<td>31 days or more</td>
<td>7.8%</td>
</tr>
</tbody>
</table>

Kerosene oil [30]
Lye [24, 25]
Methanol [30]
Nitric acid [30, 33]
Oxalic acid [30]
Paint [30]
Phenol [30]
Savion [30]
Sodium hydroxide [30]
Sulfuric acid [30]
Unknown [30]
Occurrence of eye injuries (VIII)

- Statistical data in Spain (Carrasco PhD, 2005, vs. 2011):

![Statistical data table]

![Statistical data table 2]

![Statistical data table 3]
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Prevention of eye injuries (I)

- Relative importance of all eye injuries:

<table>
<thead>
<tr>
<th>Hazard type</th>
<th>Risk factor</th>
<th>Commonly related tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hit</strong></td>
<td>Flying objects such as chips, fragments, particles, sand or earth</td>
<td>Cutting, grinding, masonry, carpentry, sawing, drilling, riveting, sanding, etc.</td>
</tr>
<tr>
<td><strong>Heat</strong></td>
<td>Any hot object</td>
<td>Any type of oven or stove, etc.</td>
</tr>
<tr>
<td><strong>Bio &amp; Chemical Agents</strong></td>
<td>Spray, gases, vapors and irritating mists</td>
<td>Handling chemicals, degreasing, laminate, and any blood work</td>
</tr>
<tr>
<td><strong>Dust</strong></td>
<td>Harmful dust</td>
<td>Carpentry, general dirt, etc.</td>
</tr>
<tr>
<td><strong>Optical Radiation</strong></td>
<td>Radiant energy, glare and intense light</td>
<td>Welding arcs, melting furnaces, lasers, lamps, etc.</td>
</tr>
</tbody>
</table>
Prevention of eye injuries (II)

• Role of the optometrist / medical professions
  • Incorporation in inter and multi-disciplinary teams related with occupational health

• Perception of risk
  • Educational and training campaigns using veteran workers

• Eye protection programme
  • Plant environmental survey
  • Vision screening
  • Implementation of the programme
  • Maintenance of the programme
    • Security signaling (ISO 70140)
Mechanical eye injuries (I)

- Initial classification by North (2001)

Ocular hazards

- Mechanical
  - Particles
  - Dust
  - Compression
  - Hot solids

- Non-mechanical
  - Chemical
  - Thermal
  - Electrical
  - Radiation
Mechanical eye injuries (II)

- BETT = Birmingham Eye Trauma Terminology (2008)

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye wall</td>
<td>Sclera and cornea</td>
<td>Though the eye wall has three layers posterior to the limbus, clinical and practical purposes dictate that violation of only the most external tissue (sclera) is to be considered</td>
</tr>
<tr>
<td>Closed globe injury of eye wall</td>
<td>No full-thickness wound of eye wall</td>
<td>The cornea and the sclera are not breached through and through</td>
</tr>
<tr>
<td>Open globe injury</td>
<td>Full-thickness wound of the eye wall</td>
<td>The cornea and/or sclera is breached through and through</td>
</tr>
<tr>
<td>Contusion</td>
<td>No wound of the eye wall</td>
<td>The damage may be due to direct energy delivery/shock wave by the object (e.g., choroidal rupture), or to changes in the shape of the globe (e.g., angle recession)</td>
</tr>
<tr>
<td>Lamellar laceration</td>
<td>Partial-thickness wound of the eye wall</td>
<td>The wound in the eye wall is not &quot;through&quot; but &quot;into&quot;</td>
</tr>
<tr>
<td>Rupture</td>
<td>Full-thickness wound of the eye wall, caused by a large blunt object</td>
<td>Since the eye is filled with incompressible liquid, the impact results in Instant IOP elevation. The eye wall yields at its weakest point (rarely at the impact site, rather, for instance, along an old cataract wound); the actual wound is produced by an inside-out mechanism, and tissue prolapse is almost unavoidable</td>
</tr>
</tbody>
</table>

Some injuries have a complex mechanism and are thus difficult to classify (e.g., an intravitreal BB pellet is technically an IOFB injury, but since this blunt object requires great force to enter the eye, the wound is created as if it were a rupture; see the text for more details). In such situations, the ophthalmologist can describe the injury as "mixed" (i.e., rupture with an IOFB) and select the more serious type (rupture), or the one that dominates the acute management (IOFB). Complete destruction of the eye and traumatic enucleation (see Fig. 1.1.5) are not included in the system.
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Mechanical eye injuries (III)

- BETT = Birmingham Eye Trauma Terminology (2008)
  - Primary eye care and treatment by ophthalmologists
  - Ocular Trauma Score: predicting the severity

![Diagram showing classification of eye injuries]
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Mechanical eye injuries (IV)

• Contusion injuries:
  • Causes (risk factors):
    • flying blunt objects, falling object, explosions or compressed air accidents, water jets, airbag inflation, etc.
  • Mechanism damage:
    • pressure wave traversing the (incompressible) eye fluid content
    • 1: black eye; 2: subconjunctival haemorrhage;
    • 3: corneal abrasion; 4: blow-out fracture;
    • 5: hyphaema; 6: iridodialysis;
    • 7: cataract; 8: lens subluxation due to torn zonule;
    • 9: retinal tear/detachment; 10: vitreous haemorrhage:
    • 11: commotio retinae; 12: choroidal rupture;
    • 13: scleral rupture; 14: angle recession; 15: retinal haemorrhage.
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Mechanical eye injuries (V)

• Examples of contusion injuries and glossary in zones:
  • Eyelids and orbit:
    • Black eye, ptosis, ectropion, fractures of the orbit
  • Anterior segment:
    • Subconjunctival haemorrhages, hyphaema, iris, angle recession
    • Lens: vossius ring opacity, sub-epithelial disseminated opacities, traumatic rosette-shaped or diffuse or zonular cataract
  • Posterior segment damage:
    • Oedema, cysts, holes, necrosis
    • Vascular changes, tears of the choroid and retina,
    • Retinal detachment
    • Nervous supply
Mechanical eye injuries (VI)

- **Perforating injuries:**
  - Foreign bodies (FB): subtarsal, superficial,
  - Intraocular foreign bodies (IOFB):
    - Methods of localization:
      - Non-metallic fragments: ultrasonography
      - Metallic fragments: X-rays
    - Retained IOFB:
      - Bio fragments causes infections (uveitis, etc)
      - Maximum danger: Fe (siderosis), Cu (chalcosis)
  - Lacerations:
    - Cornea and sclera, prolapse of the iris, ciliary body, etc
    - Complete disorganization of the globe
Non-mechanical eye injuries (I)

- General classification (North 2001):
  - Chemical
    - Direct vs. indirect effect according to different chemical substances
  - Thermal
    - Thermal, flame, contact burns and scalds
  - Electrical
    - Due to lightning and high-tension electrical appliances
  - Radiation
    - Ionizing (α, β, γ, X): cataract after ocular tumor treatment
    - Optical (UV, VIS, IR) → Lesson no. 4
    - Non-optical (MO, RF, etc)
Non-mechanical eye injuries (II)

• Chemical agents:
  • Direct effect (by contact)
  • Indirect effect (by ingestion, absorption or inhalation)
  • Variables:
    • Concentration, pH, exposure time
• Treatment by acids, alkalis, organic solvents, etc
  • Prognosis for eyes subjected to chemical burns
    – Grade I-IV (excellent to very poor)
  • Chemical neutralization of harmful substance
    – With water or saline: nearby presence of showers
    – Alkalis + Acid = WATER
      • pH > 11 max. danger
Non-mechanical eye injuries (III)

- Chemical agents: topical route of exposure
Non-mechanical eye injuries (III)

- Chemical agents: distribution following the systemic route of exposure
Non-mechanical eye injuries (IV)

• Chemical agents:
  • Toxic responses of the ocular and visual system
    • Drugs, herbal medicines, chemical agents
  • Methods for evaluating chemical-induced visual side effects
    • Functional tests
      – VA, color vision, visual field, CSF, ERG, photostress tests, double vision
        and ocular motility, pupil measurements, corneal sensitivity & thickness
    • Objective anatomical methods
      – Cornea and conjunctiva, tear film;
      – Lens, anterior chamber
      – Retina, intraocular pressure
Design of eye protection equipment

- Definition
- General requirements
- Typical forms
- Materials for lenses
- Materials mounts
- Control Tests
  - Physico-chemical factors
  - Spectral factors
Design of eye protection equipment

• Definición (R.D. 773/1997, de 30 mayo)
  • EPI = “cualquier equipo destinado a ser llevado o sujetado por el trabajador para que le proteja de uno o varios riesgos que puedan amenazar su seguridad o su salud, así como cualquier complemento o accesorio destinado a tal fin”

• Excluidos:
  • La ropa de trabajo corriente y los uniformes que no estén específicamente destinados a proteger la salud o la integridad física del trabajador.
  • Los equipos de los servicios de socorro y salvamento.
  • Los equipos de protección individual de los militares, de los policías y de las personas de los servicios de mantenimiento del orden.
  • Los equipos de protección individual de los medios de transporte por carretera.
  • El material de deporte.
  • El material de autodefensa o de disuasión.
  • Los aparatos portátiles para la detección y señalización de los riesgos y de los factores de molestia.
Design of eye protection equipment

• General requirements
  • Safe
    • constructed so that it does not impair visual function
  • Efficacy:
    • constructed to provide the necessary protection against the hazard for which it is designed
  • Comfort: during wear and not liable to condensation
  • Lightweight: and not interfere with movements
  • Easily cleaned
  • Readily replaced at reasonable cost
  • Durable, non-flammable and non-irritant to the skin
  • Of suitable optical quality
  • Cosmetically acceptable
  • Compatible with other protective devices
Design of eye protection equipment

- Typical forms: INSHT website
  - Eyeshield
  - Eyeshield integral (uni or biocular)
  - Cups rimmed glasses (goggles)
  - Face shields
  - Welding screens (hand, head, helmet attachable to the industry)
Design of eye protection equipment

• Employers should ensure that workers wear PPE required optical prescription required prescription that incorporate or use PPE on his regular spectacle

• Materials for lenses
  • Glass (crown)
  • Plastic (CR-39, PMMA, polycarbonate)
  • Wire netting

• Materials mounts
  • Metal (Ni alloy)
  • Injected plastics: polycarbonate, polyamide, etc.
Design of eye protection equipment

- Tests of physical control - chemical (I)
  - Impact resistance
  - Points to check:
    - Abrasions / scratches surface
    - Size / velocity of the projectile
    - Lens thickness
    - Material type
  - Comments:
    - $\downarrow$ Resistance in $P_f' < 0$
    - Permanent radial fractures optical glass
    - Shear fractures and fragments in CR-39
Design of eye protection equipment

• Tests of physical control - chemical (II)
  • Hardness
  • Chemical resistance
    • Glass and CR-39: quite resistant
  • Thermostability
    • Polycarbonate and PMMA tend to distort more easily than glass
  • Inflammability
    • All plastics are flammable at very high T, never attainable in normal
  • Resistance to hot particles
    • Spotted glass resistance and worse than CR-39
  • Radiosensitivity
    • Glass detectable sizes> 0.5 mm
    • Plastic, very difficult to observe
Design of eye protection equipment

• Tests of optical quality
  • Polishing
  • Spectral requirements for:
    • Solar protection
    • Welding arcs
    • Lasers
    • Glare
Standards related to eye protection

• AENOR + INSHT websites:
  • Basic use (166)
  • Impact (166, 1731)
  • Fluids (166)
  • Coarse powder (166)
  • Gas and fine dust (166)
  • Solar radiation (166, 172)
  • Radiation IR / radiant heat (166, 171, 1731)
  • UV radiation (166, 170, 169)
  • Welding radiation (166, 169, 175, 379)
  • Laser radiation (166, 207, 208)
  • Molten metals (166)
  • Short circuit electric arc (166)
Standards related to eye protection

- **UNE EN - 166**: [http://www.aenor.es](http://www.aenor.es) (DOFA analysis)
- **Classification of performance**
  - Filter code (optical)
    - s / n: welding filter
    - 2: UV filter
    - 3: VIS filter
    - 4: IR filter
    - 5: Sunscreen without IR requirements
    - 6: Sunscreen with IR requirements

- **Degree of protection**

\[
N = 1 + \left( \frac{7}{3} \right) \log \left( \frac{1}{\tau_V} \right)
, \quad \text{with } \tau_V = \frac{\Phi_{\text{TOTAL transmitted}}}{\Phi_{\text{TOTAL incident}}} = \frac{780 \text{ nm}}{380 \text{ nm}} \sum_{\lambda=380 \text{ nm}}^{780 \text{ nm}} F_e(\lambda) \tau(\lambda) V(\lambda) \Delta\lambda
\]
Final message

When workers are trained to work safe, be able to anticipate and avoid work-related injuries
Supplementary reading and learning

- Download the MEDOP catalogue from lesson folder
  - Read the ocular and facial section
  - Why it is interesting?
  - Applicability level?
  - Work opportunities?
  - From other similar companies?
Proposed activity nº 4

- Relative Weight: 2.5 %
- Delivery process by Virtual Campus, section forum
- Individual Task:

  
  - Which topics have been very surprised for you? Why?
  
  - What prevention mechanisms would you propose or improve by new research activities?