Mine Health and Safety Council



MHSC

DEVELOPMENT OF AN ILLUMINATION GUIDELINE FOR THE SOUTH AFRICAN MINING INDUSTRY

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Milestone 5: Develop Draft Illumination Guideline Aimed at Reducing Accidents Caused by Poor Visibility at Workplaces in The SAMI

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EXECUTIVE SUMMARY

Adequate workplace illumination is a fundamental requirement for safe and efficient mining operations. Mining environments present complex visual conditions arising from restricted working spaces, uneven and variable surface reflectance, airborne dust, equipment movement, changing workplace configurations, and the interaction of multiple lighting sources. Inadequate illumination, excessive glare, poor light distribution and obstructed lines of sight can compromise the detection of workplace hazards, the recognition of equipment and personnel, and the execution of visually demanding tasks. These challenges highlight the need for a comprehensive, technically justified, and practically implementable illumination guideline tailored to the operational conditions of the South African Mining Industry (SAMI).

This report presents the development of a draft illumination guideline under the Mine Health and Safety Council (MHSC) research programme, with the objective of supporting improved workplace visibility and reducing safety risks associated with inadequate lighting. The guideline provides a structured reference for the selection, design, assessment, operation and maintenance of illumination systems across underground mines, opencast operations and mineral processing facilities. It is intended to assist mine operators, engineers, occupational health and safety practitioners, lighting specialists and other stakeholders in evaluating existing illumination arrangements and identifying appropriate improvements.

The guideline is developed through an integrated assessment of local and international illumination standards, published scientific and technical literature, historical mining accident information, and evidence relating to mining illumination practices. Particular attention has been given to the applicability of existing South African requirements and guidance, including relevant SANS publications, the Mine Ventilation Society of South Africa (MVSSA) Data Book, and previous MHSC-supported research. International mining and industrial lighting references are evaluated to identify supplementary provisions and established engineering practices relevant to South African mining conditions.

The evidence appraisal considered the technical basis, intended application, measurement conditions and limitations of published illumination recommendations. This approach recognises that existing numerical illuminance values are derived from different combinations of experimental evidence, professional judgement, industry experience and standards-based consensus. Consequently, the guideline does not assume that agreement between published reference values constitutes independent scientific validation. Instead, it provides transparent, source-based recommendations while identifying circumstances in which additional site-specific engineering assessment may be required.

A central outcome of the work is the establishment of a task-oriented framework for specifying and evaluating workplace illumination. Rather than applying a single illuminance requirement to all mining environments, the guideline distinguishes between workplace categories, operational activities, visual tasks and equipment-related lighting requirements. It identifies 69 selected illumination references covering normal workplace lighting, equipment assessments and emergency lighting functions. These references are organised to support the selection of appropriate criteria according to the activity being performed, the relevant measurement surface, operating conditions and assessment method.

Importantly, the guideline recognises that illuminance, expressed in lux, is only one component of an effective visual environment. Adequate visibility also depends on illumination uniformity, luminance distribution, object-to-background contrast, glare, shadows, colour-rendering characteristics, and the positioning and direction of lighting equipment. A workplace may satisfy a specified illuminance reference while still presenting signifi-

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cant visual limitations. The guideline therefore promotes a broader, performance-oriented approach in which numerical illumination requirements are considered together with the practical visibility needs of workers and the hazards associated with individual tasks.

The guideline further establishes a practical methodology for assessing illumination performance under representative mining operating conditions. It distinguishes routine lighting inspections, verification against specified numerical requirements, and validation of whether the intended visual tasks can be performed satisfactorily. The recommended assessment procedures address the selection of measurement locations and reference planes, the use of calibrated instruments, the calculation of average and minimum illuminance, and the evaluation of illumination uniformity. Particular emphasis is placed on maintaining traceable measurement records, documenting environmental and operational conditions, identifying deficiencies, and verifying the effectiveness of corrective actions. Where illuminance measurements cannot adequately characterise a visual problem, supplementary specialist assessments are recommended.

The guideline also addresses the practical challenges associated with fixed and mobile mining equipment. These include the positioning and orientation of luminaires, interference from machine structures, direct and reflected glare, shadow formation, and visibility from different operator positions. Engineering considerations are provided for improving lighting arrangements without introducing additional visual obstructions or compromising other safety requirements. The importance of appropriate equipment selection, installation, inspection, cleaning, maintenance and periodic reassessment is emphasised to ensure that illumination performance remains suitable throughout the operational life of an installation.

The technical recommendations are supported by a consolidated evidence base comprising 591 source–task records, 205 task comparisons and 304 source-value records, together with documented decisions explaining the selection and application of the proposed reference criteria. This provides an auditable basis for reviewing recommendations, distinguishing direct applications from adaptations, and incorporating new technical evidence as it becomes available.

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Several limitations remain relevant to the interpretation and implementation of the guideline. Historical accident information and available mining-practice evidence can assist in identifying workplace priorities and recurring visibility concerns; however, they do not establish a quantitative causal relationship between specific illuminance levels and accident probability. Similarly, the selected numerical references have not been independently validated as universally sufficient for their corresponding mining tasks. Further assessment is therefore required to establish their practical suitability across different mine types, working conditions and visual demands. Stakeholder consultation, practitioner feedback and subsequent field-based validation are important next steps in refining the draft recommendations.

Overall, the principal contribution of this milestone is the development of a consolidated, evidence-informed and application-oriented illumination guideline for the South African mining industry. The guideline brings together previously dispersed technical references, establishes a consistent framework for selecting and interpreting workplace illumination criteria, and provides practical guidance for measurement, improvement and maintenance. It offers a foundation for more systematic illumination management while recognising that effective workplace visibility cannot be established through illuminance measurements alone.

The next stage of the project will focus on stakeholder engagement, technical review and refinement of the draft guideline, including consideration of its clarity, practicality and applicability across representative mining environments. Subject to these activities

and further validation, the guideline is expected to support more consistent illumination assessment, better-informed engineering decisions and the progressive improvement of workplace visibility and safety throughout the South African mining industry.

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OVERALL PROJECT SUMMARY

Table 1 summarises the project plan for Quarter 4 of 2026 and the current project progress.

Table 1: Progress summary for Quarter 4, 2026.

Planned activity	Evidence available	Outstanding status
Milestone 4: Site visit	Completed	No deviation
Milestone 5: Develop draft illumination guideline	The milestone report was submitted on time.	No deviation
Milestone 6: Workshop	The workshop date and venue have been confirmed, and invitation letters have been distributed to stakeholders.	No deviation

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PROJECT AIMS AND OBJECTIVES

The project aims to:

- Conduct a comprehensive review on the following:
  - Illumination standards in the mining industry and other relevant industrial sectors.
  - Existing workplace illumination standards and Codes of Practice used in the South African Mining Industry (SAMI), including SANS, the Mine Ventilation Society of South Africa (MVSSA) Data Book and international workplace-lighting guidance. Source status and applicability are assessed separately.
  - Published evidence on lighting, visual performance, comfort and health, retaining the strength and scope of the supporting evidence.
- Analyse historical accident data to identify trends and correlations between poor illumination and workplace accidents.
- Evaluate current illumination practices in underground and open-cast mines, as well as in processing plants.
- Develop draft illumination guidelines aimed at reducing accidents caused by poor visibility in workplaces within the SAMI.
- Conduct a hybrid workshop in Gauteng with relevant stakeholders to solicit input on the draft illumination guidelines, and incorporate feedback from the workshop into the revised guidelines.

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PROJECT SCHEDULE

The project comprises seven milestones. Table 2 preserves the earlier planning schedule; its bars do not establish completion, acceptance or an agreed current deadline.

Table 2: Earlier project schedule, retained as a planning record.

	Milestone	2026 Jan	2026 Feb	2026 Mar	2026 Apr	2026 May	2026 Jun	2026 Jul	2026 Aug	2026 Sep	2026 Oct	2026 Nov	2026 Dec
1	Project initiation	■											
2	Literature review of local and international illumination standards, existing workplace requirements, and the health and safety effects of poor lighting.	■	■	■	■								
3	Analyse historical accident data to identify trends and correlations with inadequate illumination.			■	■	■							
4	Evaluate the current illumination practices in underground and open cast mines, as well as in processing plants.	Site visit planning and scheduling				■	■	■	■				
5	Develop draft illumination guideline aimed at reducing accidents caused by poor visibility at workplaces in the SAMI.	■	■	■	■	■	■	■	■	■	■		
6	Conduct a hybrid workshop in Gauteng with relevant stakeholders to solicit inputs on the draft illumination guideline.							Workshop planning and scheduling				■	
7	Draft & final report	■	■	■	■	■	■	■	■	■	■	■	■

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1 INTRODUCTION: PURPOSE AND USE OF THIS GUIDELINE

A worker needs to see an uneven walking surface, an operator needs to recognise a person beside a machine, and an electrician needs to distinguish the detail of a connection. Each relies on lighting, but each asks something different of it. In a mine, dust, water, dark surfaces, equipment and changing workplaces can make these ordinary visual demands difficult to meet. A bright lamp does not necessarily make the important detail easier to see [1, 2].

Mines already use lighting standards, equipment guidance, established practice and their own procedures. The difficulty is bringing these sources together for the work actually being done. A published illuminance value may describe a room, a task surface or a machine-light test. General industrial advice may need interpretation for a confined underground workplace or a moving machine. The person responsible for the installation needs a usable explanation of these differences, together with practical ways to improve the lighting.

This guideline is intended for electricians, engineers, occupational-hygiene and safety personnel, supervisors and other practitioners who plan, inspect, maintain or improve mine lighting. It covers representative underground, open-cast, processing and supporting workplaces, including the activities performed around and inside mobile equipment.

The purpose is to help readers identify what people need to see, understand the lighting factors that affect it, find a source-based reference value, choose a suitable lighting arrangement and check the result. The intended benefits are safer movement, better recognition of hazards, useful task performance and a more comfortable visual environment. The guide provides general principles and selected examples; it does not prescribe a complete design for every mine or task.

The recommended illuminance values presented in this guideline are derived from a critical appraisal of relevant South African and international standards, published research, and established mining industry practices. These values provide a technically informed reference for the design, assessment and improvement of workplace lighting. However, the available evidence does not permit independent validation of the numerical adequacy of each recommended value for its intended mining application. Furthermore, compliance with a specified illuminance level does not necessarily ensure adequate workplace visibility or safe visual performance. Lighting effectiveness must also be assessed in relation to the specific visual task, workplace configuration, illumination uniformity, glare, shadows, contrast, and prevailing environmental and operational conditions. Accordingly, the recommended values should be applied as task-specific reference criteria within a broader assessment of workplace visibility, rather than as standalone indicators of lighting adequacy. The recommendations may be progressively refined through further field validation, operational experience and emerging scientific evidence.

The guide principally addresses lighting for human vision. Specialist optical systems used solely for machine sensing or process instrumentation are outside its main scope. Equipment instructions and applicable site obligations remain relevant to implementation; the source comparisons in this document do not establish their legal status.

How to use the guide

This guideline is organised to guide readers progressively from the technical background and fundamental principles of mine illumination to practical applications, recommended illuminance values, performance assessment, and ongoing lighting management.

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Sections 1–3 establish the foundation of the guideline. Section 1 introduces its purpose, scope and intended application. Section 2 reviews the relationship between lighting and mining safety, together with existing illumination standards and guidance. Section 3 describes the methodology used to develop the guideline, including the evaluation of supporting evidence and the selection of recommendations.

Sections 4–7 explain lighting principles and their practical application. Section 4 introduces the fundamental concepts affecting workplace visibility, while Section 5 explains how these principles can be applied to improve lighting arrangements. Sections 6 and 7 extend the discussion to representative mining workplaces and mobile mining equipment, respectively, highlighting operational challenges and practical lighting solutions.

Sections 8–9 provide the principal technical references for implementation and assessment. Section 8 presents the recommended illuminance values for different mining workplaces and visual tasks, together with their specific application conditions. Section 9 explains how to assess lighting performance, including the selection of appropriate measurement methods and the interpretation of results.

The subsequent sections address the operation and maintenance of lighting installations, providing guidance on sustaining satisfactory lighting performance under changing workplace and environmental conditions.

For practical use, readers may proceed directly to Section 8 to identify the recommended illuminance criteria for a particular workplace or task, followed by Section 9 to determine the appropriate assessment procedure. Sections 4–7 provide supporting technical guidance where further explanation or practical improvement measures are required. The appendices provide detailed comparisons of published illuminance values, the rationale for selecting the recommended criteria, and supplementary assessment procedures and records, ensuring transparency and traceability of the guideline's technical recommendations.

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2 BACKGROUND: LIGHTING, SAFETY AND EXISTING GUIDANCE

2.1 Why visibility deserves attention

Mining work depends on recognising information in time to act: a person near a machine, an edge in a travel route, a change in ground condition, a mark on a gauge or a defect in a component. The visual demand changes with the size and position of that information, movement and the time available to see it. Lighting is one influence on this process, alongside the task, the observer and the physical layout [1, 2, 3].

Research on mining lamps and equipment lighting has examined outcomes such as detecting objects and experiencing glare. These studies show why the arrangement and distribution of light deserve attention as well as its quantity. Their conclusions apply to the tested equipment, people and conditions; they do not establish one numerical threshold for every mining task [4, 5, 6].

Accident records provide another perspective. The project's historical analysis identifies assigned illumination causes, narratives describing visibility problems and broader circumstances in which seeing the relevant information may matter. These are different evidence categories. A failure to see is not automatically a measured lighting defect, and a recorded illumination cause does not supply the complete visual conditions of an event. The findings help focus attention on tasks and interactions, without proving that a particular lux value would have prevented an accident.

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2.2 The mining context

Underground workplaces may have little useful daylight, irregular geometry and dark or contaminated surfaces. Advancing development changes where work occurs. Equipment and people can interrupt the light path or the line of sight. Surface operations add changing daylight, large working distances, weather and interactions between vehicles and workers. Processing plants combine movement, machinery, instruments, inspection and maintenance within one installation [1, 2, 7].

Mine engagement also shows that lighting is an ongoing service. Contamination, damage, access for cleaning, replacement fittings and changing work arrangements influence what is available to the worker. Interviews describe how mines respond to these difficulties; supplied surveys describe particular measured conditions. Neither form of evidence establishes an optimum arrangement or maintenance interval for all mines.

These practical differences explain why a guide must connect a place to the activities performed there. A workshop includes travel, ordinary repair and detailed inspection. A vehicle includes a travel view, a working attachment, cab information and access steps. A single area name does not describe all those visual demands.

2.3 Accident mechanisms, trends and mine areas

The Milestone 3 analysis contains **67,223 accident records from the 2005–2024 annual SAMRASS dataset**. Figure 1 shows the seven named accident-mechanism groups used in that analysis, covering 57,029 records. The remaining 10,194 records are classified as *Other or unclassified* and are omitted from the plots. These are counts of records rather than counts of people or exposure-adjusted risks. The existing mechanism classifications do not establish the activity, surface condition or cause of each event.

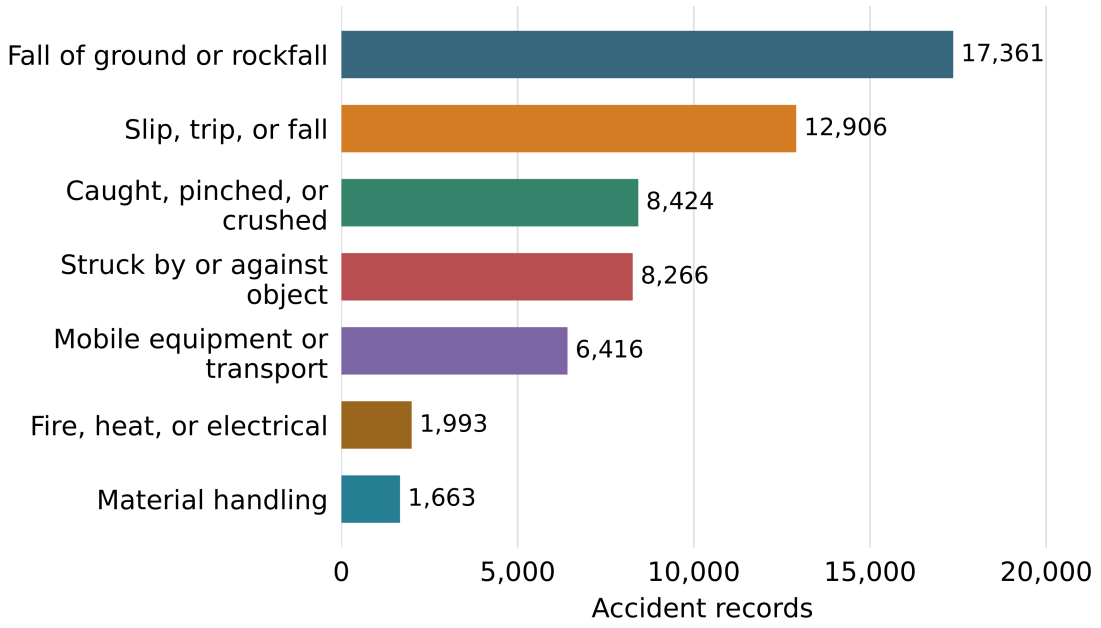


Figure 1: Accident records by mechanism, SAMRASS 2005–2024.

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How the recorded burden changed. Figure 2 follows the same seven mechanisms through the twenty annual exports. Fall of ground or rockfall is separated from the other mechanisms, and the two smaller groups have their own panel, so their changes remain visible. Each panel starts at zero but uses its own vertical scale. The year is the annual export year used in the saved analysis; some accident dates precede that export year.

The decline is uneven. Fall-of-ground or rockfall records fell from 1,452 in 2005 to 489 in 2024 (66%), while slip, trip or fall records fell from 645 to 541 (16%). The contrast also holds beyond these endpoints: comparing annual mean counts in 2005–2009 with 2020–2024 gives reductions of 64% and 20%, respectively. Slip, trip or fall remains a substantial recorded burden and exceeds fall of ground or rockfall in every export from 2020 to 2024.

Other mechanisms followed different patterns. Over the same five-year periods, mean counts declined by 52% for struck by or against object, 44% for caught, pinched or crushed, 34% for mobile equipment or transport, and 20% for material handling; fire, heat or electrical increased by 27%. These are recorded counts, not exposure-adjusted risks. The comparison does not control workforce, production, reporting or operating conditions, including those in 2020, and cannot establish prevention priorities or attribute changes to lighting. Any lighting link requires review of accident circumstances and separate evidence.

The areas within mines. Table 3 places **recorded mine areas in the rows** and **accident types in the columns**. Areas include stopes, haulages, gullies and bord-and-pillar workings. The twelve most frequent named source areas are followed by source-coded *Other*, remaining named areas and missing locations. Source labels are retained without merging similar names. All eight mechanisms, including *Other or unclassified*, remain: each record contributes to one cell and both margins reconcile to 67,223 records.

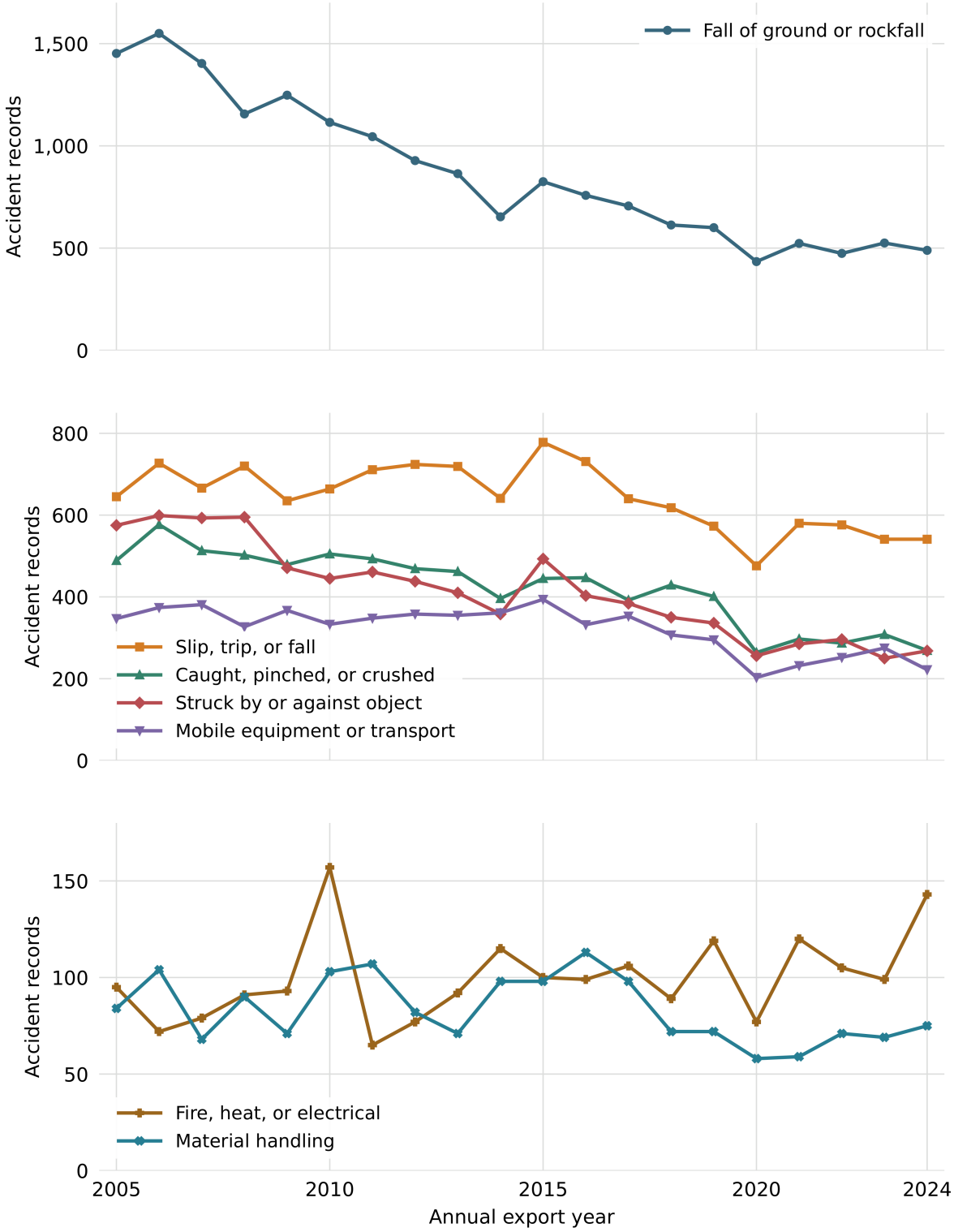


Figure 2: Annual records in the seven named accident-mechanism groups, SAMRASS 2005–2024. The aligned panels use different zero-based vertical scales: fall of ground or rockfall above, four other mechanisms in the middle, and fire/heat/electrical and material handling below. Colours match Figure 1. *Other or unclassified* is excluded; counts are grouped by annual export year.

Table 3: Accident records by mine area and accident type, SAMRASS 2005–2024.

Recorded mine area	Fall of ground or rockfall	Slip, trip, or fall	Other or unclassified	Caught, pinched, or crushed	Struck by or against object	Mobile equipment or transport	Fire, heat, or electrical	Material handling	Total
Stope working face	6,365	1,217	1,382	971	1,624	93	62	198	11,912
Crosscut or drawpoint crosscut	1,472	1,053	640	840	889	752	45	152	5,843
Haulage	989	1,103	653	908	679	822	84	151	5,389
Strike gully or cutting	994	363	303	257	433	11	11	42	2,414
Centre gully	636	544	331	271	504	14	16	54	2,370
Raise (incuding poleway)	917	330	278	168	266	16	5	26	2,006
Opencast	60	352	524	225	141	360	182	68	1,912
Development or reef drive	646	275	211	176	196	172	19	34	1,729
Bord and pillar (continuous miner)	469	220	0	0	0	894	0	0	1,583
Tip	477	153	123	227	182	86	11	23	1,282
Boxhole or orepass	456	215	162	121	178	38	18	11	1,199
Shaft station	46	281	213	241	149	73	17	56	1,076
Other (source-coded)	364	554	520	423	266	196	135	85	2,543
Remaining named locations	3,427	6,208	4,730	3,585	2,744	2,882	1,384	754	25,714
Location not recorded	43	38	124	11	15	7	4	9	251
All records	**17,361**	**12,906**	**10,194**	**8,424**	**8,266**	**6,416**	**1,993**	**1,663**	**67,223**

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Slip, trip or fall at stope-related locations. Slip, trip or fall events account for 12,906 records in the saved SAMRASS analysis. Table 4 shows selected individual location labels within that mechanism group, including travelling ways not listed separately in Table 3. These are exact source labels, rather than a combined classification of all stope accidents.

Table 4: Slip, trip or fall records at selected stope-related source locations, 2005–2024.

Recorded mine area	Accident records
Stope working face	1,217
Centre gully	544
Strike gully or cutting	363
Travelling way (stope proper)	319
Stope entrance/travelling way	267

The mine-area labels locate records without identifying the task, footing, or lighting conditions of each event. The trends and location counts provide background to the guide. Section 6.1 examines separately documented underground lighting arrangements and visual-performance research.

2.4 The existing lighting guidance

South African mining research, professional guidance and national standards provide complementary perspectives on mine lighting, addressing the visual demands of mining tasks, operational risks, equipment visibility and published illumination benchmarks. COL 451 [1, 8] organises coal-mine guidance around tasks, critical visual requirements and sightlines. GAP 804 [2] examines illumination and risk in gold and platinum mining. SIM 160701 [9] addresses equipment lighting and related visibility considerations. The Mine Ventilation Society of South Africa's data book [10] provides mining context and published benchmarks. SANS publications [11, 12] provide relevant indoor and outdoor lighting provisions.

International mining research, workplace standards and lighting textbooks add explanations, task provisions and design methods. They can fill gaps or describe a particular application more closely. Applying this advice to a mine requires examining the source's setting and assumptions [13, 14, 15, 16, 3].

This guideline brings these sources together to support practical mine-lighting decisions. It connects workplace descriptions to the activities performed there and explains what each selected reference applies to and how it is assessed. This helps the reader distinguish, for example, illuminance on a task from the output of a machine lamp, and use the relevant guidance when planning or improving an installation.

2.5 What published lux values can establish

Published lux values provide useful reference levels for specifying and assessing lighting. Their development may draw on experiments, accumulated practice, expert judgement or consensus. Used with the stated task, measurement plane and lighting conditions, they give practitioners a defined objective for design and a basis for assessing an installation.

The study assesses the credibility, stated basis and relevance of the sources to make reasoned reference selections. The reasoning behind individual published values is not equally traceable, and agreement between published illuminance tables may reflect a common source rather than separate scientific findings. The selections remain source-based recommendations: the available evidence does not allow the study to determine independently whether each value is numerically sufficient or insufficient for the mining task concerned.

SIM 160701 distinguishes meeting illuminance recommendations from obtaining a satisfactory overall visual environment [9]. The guideline therefore combines numerical references with practical advice on light distribution, glare, shadows and the detail that must be seen. This gives the reader a reference level together with ways to improve the visual conditions of the task. The next section explains the project's evidence appraisal; the fundamentals then explain the lighting concepts needed to use the advice.

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3 METHODOLOGY: HOW THE GUIDELINE IS DEVELOPED

The guideline brings together the project's literature review, historical accident analysis and mine-practice evidence. These sources answer different questions: what lighting knowledge is available, where visibility problems deserve attention, and what makes an improvement practical at a mine. The development process uses these contributions to explain lighting principles, organise workplaces and select published reference values. It does not derive a new relationship between lux and accident risk.

3.1 Literature discovery and appraisal

The literature examines local and international standards, previous mining projects, lighting textbooks and research on visual performance, design, measurement and maintenance. Targeted searches and the project's source collections provided candidate publications. The Milestone 2 report records the broader review; the source and decision records supporting this draft retain the passages used for particular recommendations.

Publications are assessed for their purpose, authorship or issuing body, described methods, scope and relevance to the problem being addressed. Where a recommendation was reproduced from an earlier publication, its origin was traced as far as the available material allowed. Repeated publication of the same value was not treated as independent confirmation. A file's presence in the collection or a title-level screen does not constitute a completed review of its contents.

The appraisal distinguishes scientific investigations, expert judgement, consensus guidance and reported practice where their basis can be established. Where the original reasoning behind a numerical recommendation could not be located, that limitation remains part of its interpretation. A source's credibility supports considering its advice; it does not, by itself, prove that a particular number is sufficient for a mining task.

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3.2 Historical accident analysis

The Milestone 3 analysis used the SAMRASS annual records for 2005–2024, with cleaning and harmonisation of changing fields and coding. Descriptive analysis and screening of cause fields and narratives identified circumstances in which illumination or visibility warranted attention.

An assigned illumination cause, a narrative describing a failure to see, and a broader accident mechanism are different forms of evidence. None supplies the missing measurements of the complete visual environment at the time of an accident. The findings therefore inform the choice of priority situations and questions for investigation. They are not used to calculate a safe lux threshold or to estimate the accident reduction attributable to this guideline. Outstanding dataset-review discrepancies remain matters for the accident-analysis workstream; this revision does not resolve them by rewriting the guideline.

3.3 Mine visits, interviews and supplied records

Mine engagement informed the understanding of actual activities, lighting arrangements, maintenance practices and implementation constraints. The available evidence includes interviews, documented observations, photographs, mine-supplied surveys and technical records.

These materials were interpreted according to what they record. An interview describes reported practice; a photograph establishes visible context; a survey describes measured conditions at particular places and times. Their contribution depends on the recorded task, location, equipment and operating conditions. Reported practice was not presented as a validated optimum, and an existing installation was not assumed adequate because it was in use.

The project proposal also envisaged laboratory tests, simulations and a design/assessment tool. Those commitments are distinct from the evidence supporting this draft. No completed numerical validation is claimed on their basis. The practical workflow and record in this guideline support assessment, but their inclusion does not establish delivery or validation of a separate assessment tool.

3.4 From evidence to recommendations

Table 5 shows how the evidence is used. The practical chapters combine these contributions rather than repeat the earlier milestone reports.

Table 5: Contribution of the project evidence to the guideline.

Evidence	Contribution and boundary
Research and textbooks	Explain visual conditions and supported design responses; an arrangement study does not validate every published lux value.
Standards and mining guidance	Supply reference recommendations, intended uses and assessment methods; applicability and numerical sufficiency remain distinct.
Accident analysis	Identifies priority circumstances and visual information that may matter; does not establish a lux–accident threshold.
Mine engagement and records	Identify practical difficulties and conditions; interviews, observations and measurements retain their separate meanings.
Stakeholder feedback	Can test clarity, relevance and feasibility when obtained; agreement alone does not validate a numerical threshold.

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Relevant South African sources are considered first: the MVSSA data book, SANS publications and previous mining projects. This is a local preference, with no fixed ranking between those sources. An international provision may be used where it fills a gap or more closely describes the task and conditions; the reason is recorded. Local origin is not evidence of greater numerical adequacy.

For each application, the appraisal identifies what must be seen, compares the relevant published provisions and records a selected reference with its task and measurement conditions. It checks that apparently competing numbers actually describe comparable tasks and quantities. Values are not averaged, the largest value is not selected by default, and reproductions are not counted as independent support. Direct use and project adaptation remain distinguishable: an adopted task plane, point-minimum interpretation or equipment application is recorded separately from the source's published wording.

The procedure was first applied to a general workplace, detailed inspection and mobile equipment. Those historical pilots tested whether the method exposed ambiguity and produced an understandable record; they were not tests of visual performance. The subsequent appraisal completed selection decisions for all nine application groups previously left unresolved. Section 8 presents the expanded schedule of 69 reference criteria, including

area minima, task averages, directional equipment checks and emergency criteria. Appendix B records the current selections, source conditions and direct or adapted application. Appendix A preserves the fuller published comparison, including material not selected for the schedule.

The illuminance recommendations in this guideline are drawn from published sources and provide practical reference values for mine lighting assessment. Their basis in scientific investigation, expert judgement or consensus is identified where this can be traced. These values should be applied with consideration of the visual demands of the task, site conditions and other factors affecting visibility. Achieving a recommended illuminance level forms one part of the assessment, which should also establish whether workers can clearly see the details needed to perform the task under the relevant operating conditions.

The recommendations reflect the evidence reviewed for this study and may be refined as additional relevant evidence is identified. Findings on the benefits of a particular lighting arrangement should be interpreted in relation to the conditions tested, with their wider applicability assessed before they inform a general task illuminance target. Similarly, conformity with a selected specification demonstrates that its requirements have been met under the assessed conditions; the visibility of task details and hazards should also be assessed for the workers concerned.

Site conditions may justify selecting a different task reference, modifying the lighting arrangement, changing the assessment conditions or revising the illuminance target. Each adjustment should be supported by relevant evidence, with its rationale and underlying assumptions documented to support subsequent evaluation. Adjustments should be determined for the particular application, as the guideline does not prescribe a universal multiplier.

Further development should include practitioner review, followed by field and experimental evaluation. Practitioner review should first assess whether the explanations are clear and the examples can be applied in practice. Field and experimental work should then examine the intended visual outcomes under representative tasks, worker viewpoints, equipment states and environmental conditions. These activities are proposed next steps, with their completion, methods and findings to be documented separately.

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4 FUNDAMENTALS: UNDERSTANDING LIGHTING AND VISIBILITY

Good workplace lighting helps people find their way, recognise hazards and see the detail needed to do their work. Its aim is to support safe movement, accurate work and visual comfort [3][17]. This depends on the whole view presented to the worker: the light reaching the task, the light reflected towards the eye, and the surrounding conditions. The following explanations give names to these familiar relationships and show how they affect seeing. The diagrams are conceptual teaching examples; reproduced photographs and simulations are identified in their captions.

4.1 Start with what the person must see

Seeing a gauge is different from reading its scale. Noticing something beside a machine is different from recognising that it is a person and judging where that person is moving. The information needed to perform an activity is its **visual task**. Servicing a machine, for example, can involve locating a fastener, reading a marking and examining a surface for damage. Walking to the machine requires other information: the route, changes in level and obstacles [3].

The same detail becomes harder to distinguish as it appears smaller in the worker's view. A marking that is clear at arm's length may be difficult to read from across a workplace. Movement can also leave less time to recognise the information. This is why reading a stationary label and noticing a person while manoeuvring a machine place different demands on vision [13].

The viewpoint matters too. A feature visible from an aisle may be hidden from the operator's seat. Lighting helps reveal information along an available line of sight; a physical obstruction can prevent that information reaching the observer [1, 2]. Understanding the visual task therefore begins with the person, the information and the position from which it must be seen.

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4.2 Light reaching the task and light reaching the eye

Think of a worker looking for a bolt on a workbench. Light reaches the bolt and the surrounding surface, and some of it is reflected towards the worker's eyes. Seeing the bolt depends on both parts of this path: light must reach the task, and useful differences in the light coming from the scene must reach the observer.

The light arriving per unit area is called **illuminance**, measured in **lux** (lx). Its value depends on the position and orientation of the surface. Keep a card in the same position within a broad beam from one direction, then tilt it. As it faces the beam less directly, less light reaches each unit of its surface. In a workplace, a reading taken flat on the bench describes that plane. It does not automatically describe an upright gauge beside it [13].

The light coming from a surface in a particular viewing direction, relative to its apparent area in that view, is described by its **luminance**. This quantity also applies to surfaces that emit their own light, such as a display. It helps describe the pattern of light presented to the eye. The brightness a person experiences also depends on the surrounding view and how their eyes have adjusted to it. Luminance is measured in candelas per square metre (cd/m^2) [3].

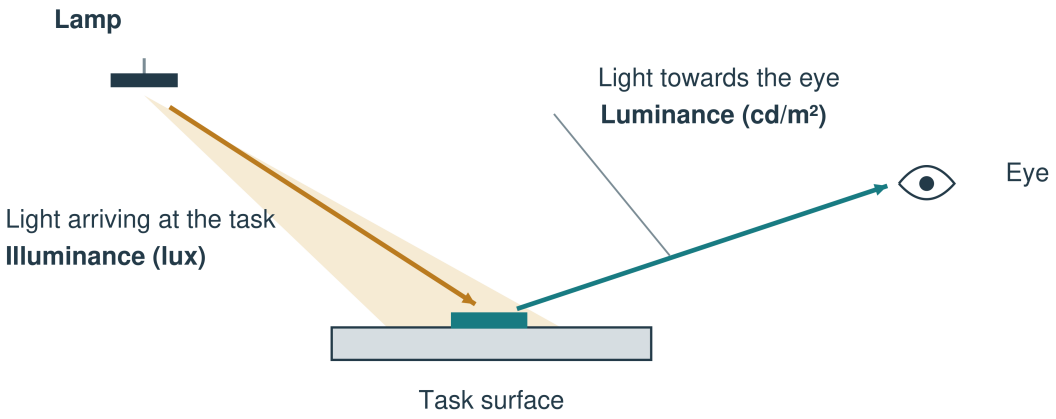


Figure 3: Light arriving at the task and light travelling towards the observer are different parts of the same path. The relevant task surface can be horizontal, upright or inclined.

Lamp packaging often gives the output in **lumens**. This is the lamp's total light output, called **luminous flux**. How much reaches a particular task also depends on the beam, distance, surface orientation and obstructions. A high-output lamp can therefore leave a task poorly illuminated when much of its light falls elsewhere [3].

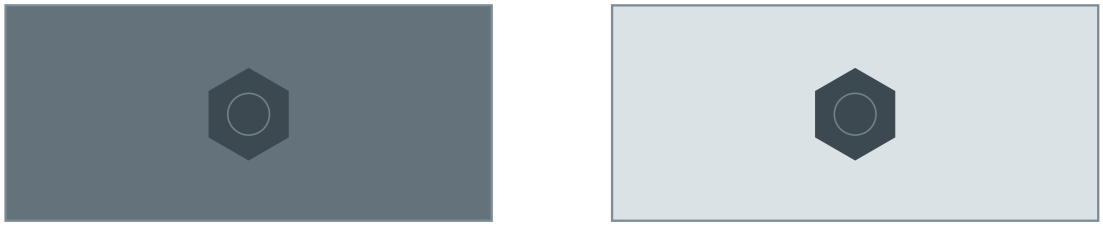
4.3 Reflectance and contrast: making the detail stand out

A dark bolt and a pale workbench can receive similar illuminance while sending different amounts of light towards the worker. **Reflectance** describes the proportion of arriving light that a surface reflects. A pale matte surface generally reflects more than a dark matte surface, which helps explain why the same lighting can produce quite different-looking surroundings [3].

A detail stands out because it differs from its **immediate background**: the surface or scene directly behind or around it in the worker's view. This difference is called **contrast**. Dark print is easier to distinguish from pale paper than from a similar dark background. Lightness and colour differences can both help reveal information.

Contrast and light level work together. If a page is evenly lit and then the lighting is reduced, the words can become harder to read even though the print and paper have not changed. Their physical contrast can remain much the same while the eye's ability to detect it deteriorates. More light can help reveal contrast already present, but the benefit also depends on the size of the detail and the viewing conditions [13][3].

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Dark bolt on dark surface

Same bolt on pale surface

Figure 4: The same detail can be easier to distinguish against a different immediate background. This comparison illustrates contrast; the text explains separately how light level affects its detection.

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The direction of the reflected light matters as well as the amount. A matte painted surface spreads reflected light in many directions; this is **diffuse reflection**. A shiny or wet surface can send a strong reflection towards particular viewpoints; this is **specular reflection**. A lamp's reflected image may appear on a surface from one position and disappear when the worker moves. Real surfaces can combine both behaviours [13].

A strong reflected image can reduce the contrast of the detail itself. It can mask the print on a glossy picture, as Figure 5 shows, or hide the scale behind a gauge window. This masking effect is a **veiling reflection**; it depends on the relationship between the light source, reflecting surface and observer. Considerable light can reach the task while its detail remains difficult to see [3].

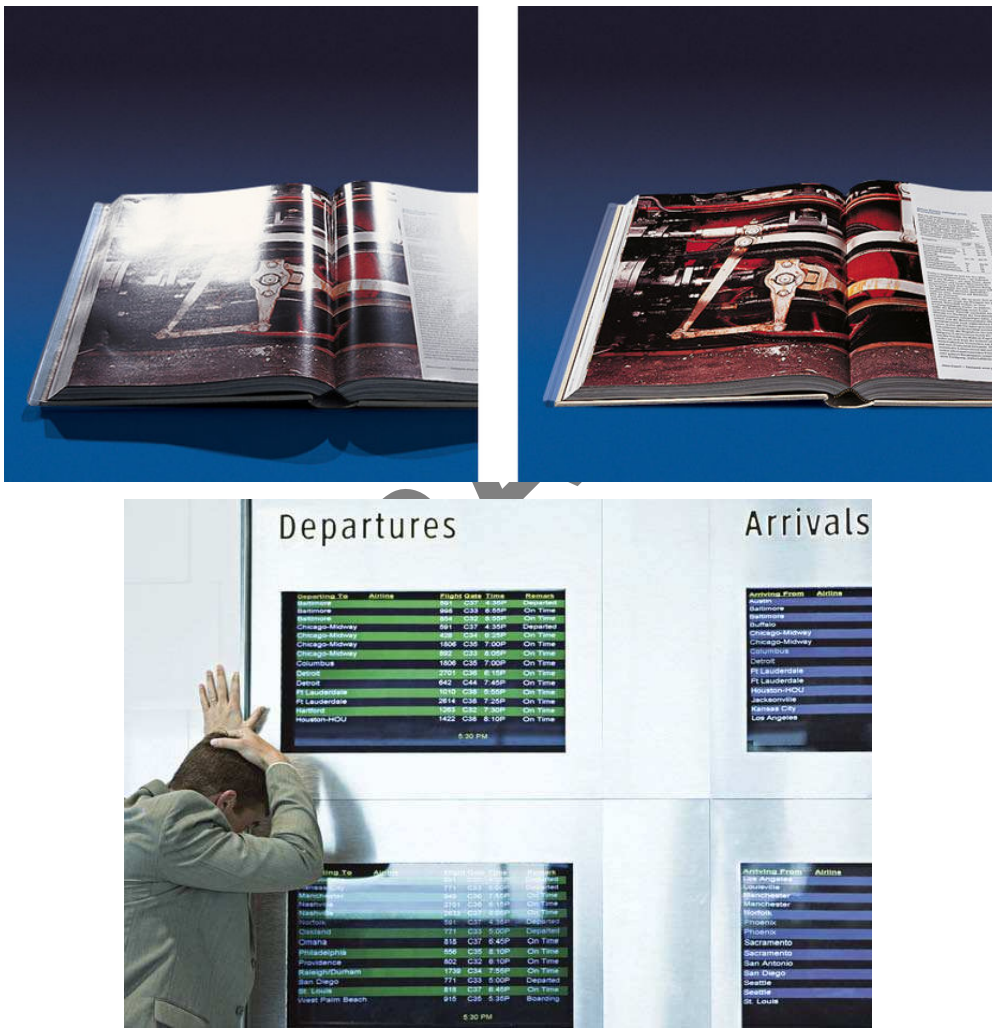


Figure 5: Top: glossy printed picture with a strong masking reflection (left) and reduced reflected glare (right), reproduced from [18]; images: TRILUX Lighting Practice. Bottom: a bright reflection masks rows of flight information on the lower displays. This is a single photographic scene. Reproduced from [19]; photograph: © Frederic Cirou/PhotoAlto/Corbis.

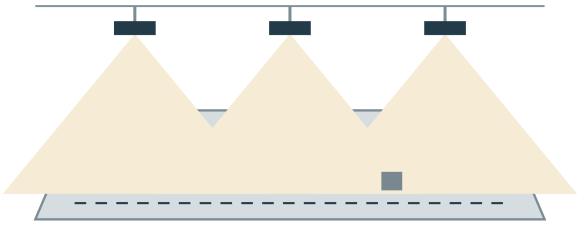
On a mine instrument, the corresponding problem is a reflection covering the needle, scale or displayed reading. The information must remain readable from the normal operating position. Relocate or shield the reflecting light source, or adjust the instrument's orientation where practicable, so that its reflection leaves the reading surface while useful task lighting remains [3].

4.4 Distribution, uniformity and shadows

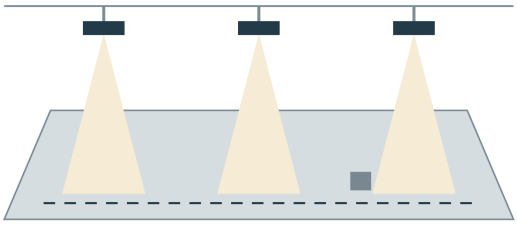
On one route, the light may extend across the walking surface. On another, bright pools may alternate with darker patches. **Distribution** describes where the light falls. **Uniformity** describes how evenly illuminance is distributed over a defined area.

An average combines readings across the assessed area. Two areas can have similar averages while differing greatly in their darker parts. The bright pool does not reveal an obstacle that remains in a dark patch. The useful question is how the pattern relates to the information people need along the route or over the task. Section 9 explains how measurements describe that pattern [3][17].

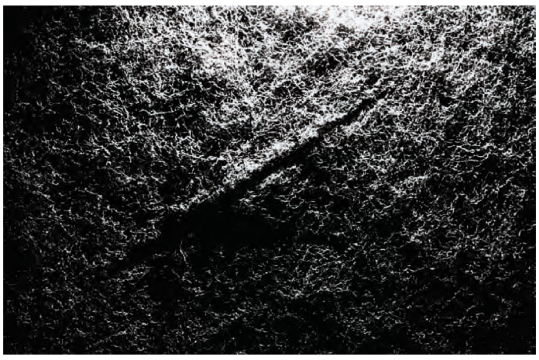
A **shadow** forms when an object blocks light coming from a particular direction. A machine structure, tool or the worker's body can cast a shadow over a fastener or marking. Yet shading also helps reveal shape: a lit face beside a shaded side can make an edge or raised feature easier to recognise. The important distinction is between shading that reveals the form and shadow that conceals the information needed [3][17].



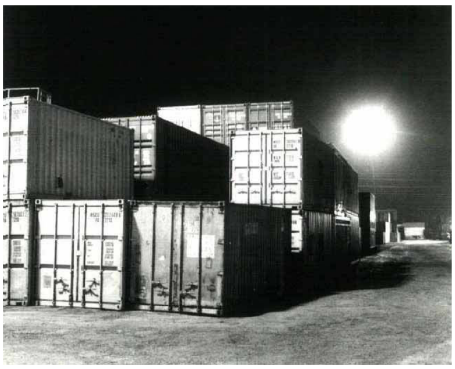
More uniform lighting



Less uniform lighting



Directional light reveals detail



Obstructions create shadowed areas

Figure 6: Top: conceptual examples of more and less uniform route lighting. Bottom left: highlights and shadow reveal a cut in textured material, reproduced from [3]; copyright 2009 The Society of Light and Lighting. Bottom right: containers obstruct lighting, leaving shadowed areas, reproduced from [17]; Crown copyright 1997.

4.5 Glare: loss of visibility and visual discomfort

At night, approaching vehicle lamps can make the road beyond them difficult to see. A bright source has entered a much darker view. Light from that source is scattered inside the eye, creating a veiling effect that reduces the apparent difference between objects and their backgrounds. The resulting loss of visibility is called **disability glare** [13][14].



Figure 7: CAD and photographic pathway views (left pair) and corresponding eye-model simulations of disability glare (right pair). The simulated veiling luminance reduces the contrast of the path and surrounding detail. Reproduced from [20]; copyright 2015 The Authors, CC BY-NC-ND 4.0.

A bright source can also feel unpleasant, distracting or uncomfortable to look towards. This is **discomfort glare**. The effects can occur separately or together: visibility can deteriorate without obvious discomfort. Whether a lamp interferes with seeing depends on its brightness, its position in the view and the surrounding scene [17][3].

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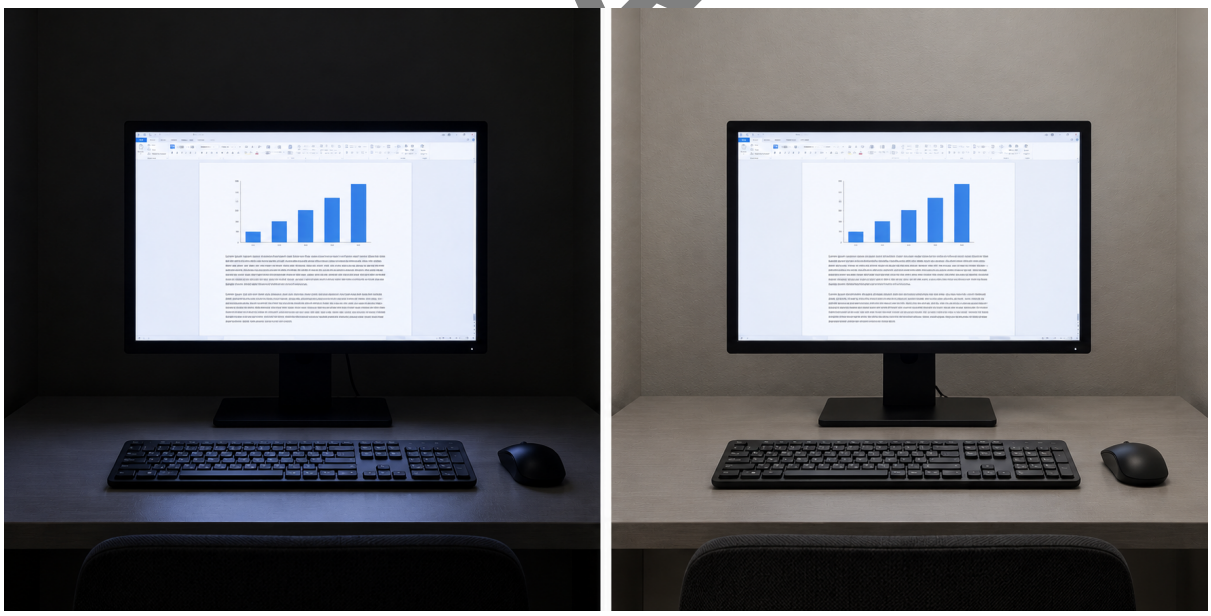


Figure 8: The same bright screen in a dark room (left) and with ambient room lighting (right). Raising the brightness of the surroundings reduces the brightness contrast between the screen and the room.

A bright source may be seen directly or by reflection. Section 4.3 explains how a surface reflection can mask detail on the task [3].

4.6 Adaptation when looking between bright and dark areas

Leaving a bright room for a dark outdoor area is a familiar example of the visual system changing its sensitivity to the surroundings. This process is called **adaptation**. During a substantial change, detail can initially be harder to recognise while the visual system adjusts [3].

Recovery is initially faster through the **cones**, used for colour and fine detail, followed by slower recovery through the **rods**, which support vision at very low light levels. Adaptation also matters when an operator looks from bright cab instruments to the darker outside view. The recovery time depends on the exposure and viewing conditions [13].

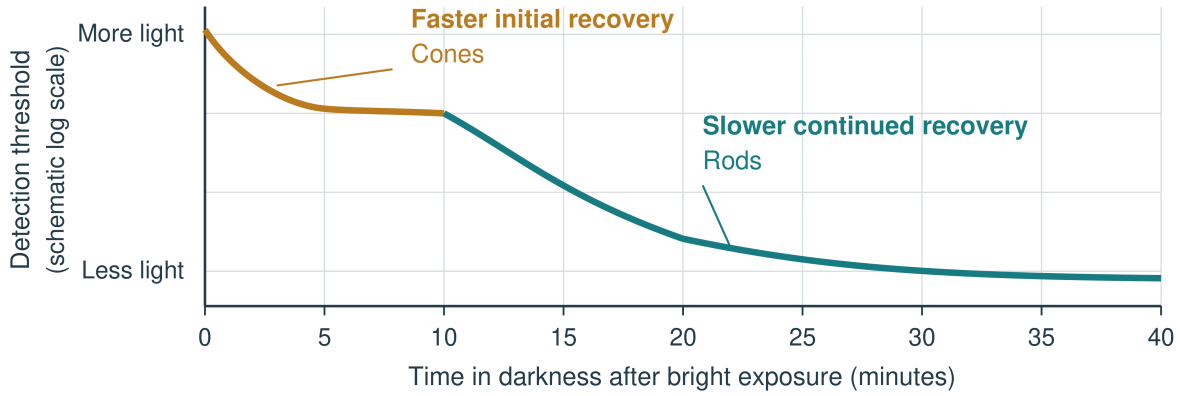


Figure 9: Schematic dark-adaptation curve, adapted from [13].

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This is why the surroundings deserve attention alongside the task itself. The relevant question is whether the information remains recognisable as the worker's attention moves between the views.

4.7 Colour appearance and colour recognition

A worker may see the outline of a cable clearly yet struggle to distinguish its insulation colour from another cable. Object colour depends on the light available from the source and the light reflected by the surface. Different sources can therefore make the same coloured markings look different [13][17].

Colour rendering describes how object colours appear under a light source relative to a reference source. It matters when colour carries information: cable insulation, painted identification marks and printed warning labels must remain distinguishable under the working light [3].

The **Colour Rendering Index (CRI)**, commonly shown as R_a, gives a numerical indication of this property. The general index compares eight standard test colours under the lamp with their appearance under a reference light of the same correlated colour temperature. A value of 100 represents agreement for those test colours; higher values indicate a closer average match. **CRI 90 does not mean that 90% of colours are correct** [3, 21].

This number deserves attention because a light can look bright and white while making important object colours less distinct or changing their appearance. Two lamps with the same warm or cool appearance can have different spectral compositions and colour rendering. The loss matters when colour identifies a component or carries an instruction. Choosing a source with suitable colour rendering helps preserve that information; increasing light output alone does not establish it [3].

Colour appearance describes the light itself, often experienced as warm or cool. Equipment information expresses this through colour temperature or correlated colour temperature, given in kelvin (K). Warm or cool appearance alone does not establish how well a source reveals particular object colours [3].

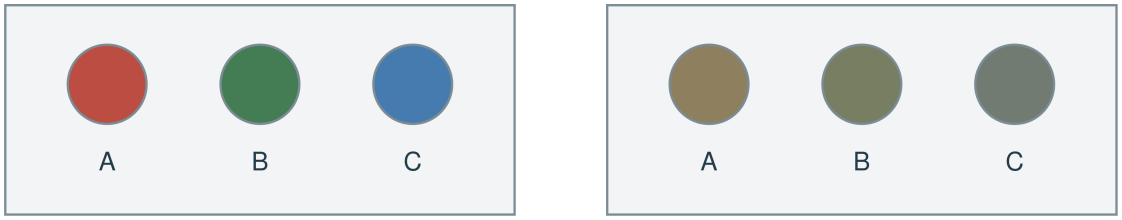


Figure 10: The same markings can become harder to distinguish under different lighting. This conceptual comparison concerns colour recognition, rather than the warm or cool appearance of the light.

Reading and using the rating. Look for **CRI** or R_a on the box or manufacturer's datasheet, alongside the separate lumen and kelvin ratings. Figure 11 highlights a real example. Include colour rendering when specifying a replacement lamp where colour identification matters. The index is an average, so even a high score can conceal weak rendering of a particular colour. Compare the relevant manufacturer information and the actual markings or materials under the proposed light; the required result is that the task's colour distinctions remain recognisable [3, 21].

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Figure 11: The printed CRI 90 rating is boxed on this lamp package and enlarged at right. It describes colour rendering, separately from light output in lumens and the light's colour appearance. The pictured rating is a label-reading example. Photograph published by Reduction Revolution [22]; highlighting and enlargement added for this guide.

4.8 Flicker and the appearance of moving machinery

Light output can vary over time. When that variation is visible as changing brightness, it is called **flicker**. This may be experienced across a lit area or at an individual source [3].

Varying light can also change the apparent movement of a part that rotates or moves back and forth. If successive flashes reveal a rotating marker at the same position, it can appear stationary; other relationships can make movement appear slower or reversed. These are **stroboscopic effects**. They can occur even when the source appears steady to the eye, so the absence of noticeable flicker does not establish an accurate appearance of motion [13][17].

An ordinary lux reading does not describe these changes over time.

Putting the concepts together

The goal is a clear, comfortable view that lets people recognise the information they need accurately and in time to act. The amount of light, the way surfaces reflect it and the contrast between a detail and its background all affect what can be seen. Distribution and shadows reveal or conceal shape; glare and reflections can obscure detail. Changes between bright and dark views affect how the eyes adjust, while colour and variations in light over time affect how markings and movement appear. These factors work together in the worker's view [3]. Section 5 applies them to lighting decisions for the task and its surroundings.

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5 PLANNING AND DESIGNING MINE LIGHTING

A lighting design is a choice about where light should come from, where it should fall and what the worker should be able to see. Start with those relationships before choosing the number or power of the fittings. This chapter develops an arrangement, then explains how to change it when illuminance, uniformity, glare, target visibility or shadows are unsatisfactory. The recurring examples are a workshop inspection task and an underground route beside obstructing equipment. Their drawings and numerical inputs are illustrative, not measured installations or additional mining limits.

5.1 Build the design from the task and the view

Use the following sequence for a new installation or an improvement. Each step produces information needed for the next decision [14, 3].

1. **Draw the task and the view.** Mark the detail, its surface, the worker's eye position and direction of view. Add the route, structures and equipment positions that can interrupt either the light path or the sightline.
2. **Write the design basis.** Specify the task, numerical reference and its meaning, together with the visual result required. Identify the conditions in which both must be achieved.
3. **Choose the lighting approach.** Decide which parts need general coverage, which known work areas need localised provision and which details need supplementary task lighting.
4. **Develop a layout.** Choose candidate optical distributions and protected mounting positions. Predict light on the relevant surfaces using the actual geometry and fitting data.
5. **Resolve the weak parts.** Redistribute light, remove an offending source or reflection, reveal the target and manage shadows using the methods below. Reassess the effects on other requirements after each change.
6. **Compare and verify.** Compare arrangements that can perform the work, specify the selected equipment and settings, and verify the installed result against the same tasks and conditions.

For the workshop example, lighting the bench is an incomplete brief. The worker must read an upright gauge, locate a fastener and examine a component while handling a tool. Mark each surface and the normal standing or seated positions. A hand can interrupt the lamp-to-fastener path even when the empty bench is well lit. The gauge glass can reflect another fitting into the eye.

For the underground example, draw the walkway beside the equipment in plan and side view. Mark the floor edge, a low obstruction and the approach positions. Include structures that can shade the floor and seated or crouched workers who may see a fitting below another person's usual line of sight. Show the movement of attachments, covers and materials. Distinguish a target that is unlit from one that is physically hidden [14, 1].

Add feasible fitting locations, supply routes and maintenance access. This exposes conflicts early: a recess can cut off the useful beam; a bracket can face an approaching worker; a light above a machine may not reach the ground beside it. A drawing showing

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only lamp positions cannot resolve these conflicts. Carry the task/view drawing through the design [14].

5.2 Set a criterion for the task and its surroundings

Use Section 8 to find a source-based reference for the activity. Record the assessment area, surface orientation, lighting contributions, operating state and whether the reference concerns an average, a minimum or a maintained value. A minimum maintained average is a lower bound on an area average; it is not a requirement that every point equal that number. Retain the source's actual meaning [11, 12].

A detailed-inspection reference belongs to the inspection task. It need not be applied to the entire workshop. The approach route, tools and adjacent work still need appropriate provision. Apply source relationships between task areas, immediate surroundings and background within their stated scope; do not transfer indoor area relationships automatically to an irregular excavation [23, 15].

The W1–W8 workplace families in Section 8 provide a route to the reference tables. Appendix A retains the complete area index and published comparisons; a family name does not replace the task definition.

Write the functional requirement beside the numerical one: for example, the worker must distinguish the gauge pointer and adjacent graduations from the normal working position, with the protective window in place. For the route, identify the edge and obstruction to be recognised during approach. Establish distance and work state from the actual task; this guide supplies no universal detection distance.

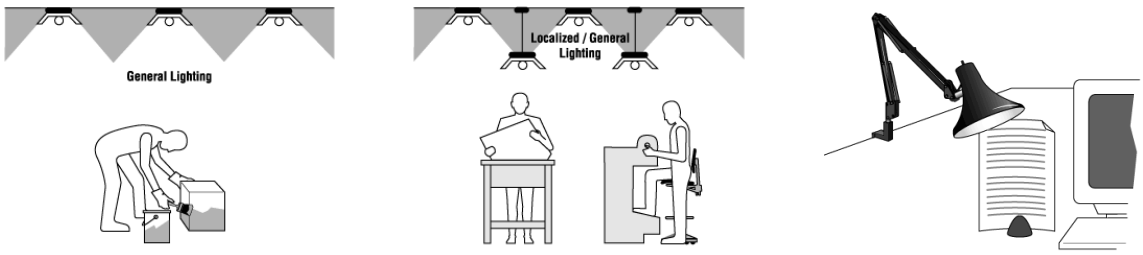
If the task changes, seek the reference for the new task. If a reflection, blocked beam or contaminated cover causes the problem, correct that mechanism. Any source-based adjustment to illuminance must retain its conditions; it is not a general multiplier for difficult workplaces. Keep a missing or ambiguous criterion unresolved until its basis is clarified.

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5.3 General, localised and task lighting

General lighting distributes light over the working space. It is useful where movement or work is spread across that space or its positions change. **Localised lighting** concentrates provision at known work areas. **Task lighting** places additional light at a particular task, often together with general lighting. These are choices about arranging light, not three universal lux bands [3].

Figure 12 distinguishes light across a space, additional overhead lighting at known work areas and a nearby light directed at the task. Figure 13 shows industrial examples of these arrangements. The combined provision at the task and the useful lighting of the surroundings must be considered together. A task lamp is not a reason to leave access or adjacent activity poorly lit.



(a) General lighting (b) Localised general lighting (c) Local or task lighting

Figure 12: General lighting serves the space; localised general lighting adds provision at work areas; a local or task light directs additional light at the work. Illustrations reproduced from the Canadian Centre for Occupational Health and Safety (CCOHS) [24].



(a) General workshop lighting (b) Localised lighting (c) Task lighting for inspection

Figure 13: Industrial examples of general, localised and task lighting. Source credits: (a) The Society of Light and Lighting, Boyce and Raynham [3]; (b) THORN EMI Lighting Ltd., article by R. I. Bell [25]; (c) Health and Safety Executive, Crown copyright [17]. The photographs show different installations.

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Inspect the arrangement from the worker's position. A hand, tool or machine part can shade the task; a reflection can hide a marking. A useful local light should improve the required view without creating a new difficulty for the worker or somebody nearby. Where daylight contributes, also consider the condition when that contribution is reduced or absent [3].

Choose the approach from the extent and stability of the work. General lighting serves dispersed work or changing positions. Localised lighting serves fixed work areas with different needs or large obstructions. A task light supplies extra light, a different direction or particular colour-rendering quality to a detail. In the workshop, overhead coverage can serve movement and handling while a shielded task light serves inspection. Underground, a light beyond an obstruction can supplement route coverage without replacing lighting of the approach [3, 16].

5.4 Develop the layout and select the complete fitting

Choose a distribution that reaches the required surfaces. A narrow beam concentrates light over a limited region; a broad distribution spreads the contribution. An asymmetric distribution can direct more light towards one side of a route. Compare actual photometric data rather than these descriptions alone. Equal wattage or lumens does not establish equal task illumination [26, 16].

Obtain the manufacturer's photometric data for the complete luminaire, including its specified lens, diffuser, guard and operating setting. These data describe where its light

goes and allow the proposed installation to be calculated. They may include lux tables at stated mounting heights, equal-lux contour diagrams or an electronic photometric file. A changed optic or incorrectly rotated asymmetric fitting can redirect light even when total output is unchanged [26].

Place candidate fittings on the task/view drawing before committing to equipment. Include actual surfaces, obstructions and assembled mountings so the proposed light paths can be checked against the worker's views. The following subsection explains how to size the output and check the arrangement [26, 16, 14].

Mount for optical performance and survival. Keep fittings outside equipment swept paths or protect them through engineered recesses or guards that preserve the required beam. Provide access for cleaning and replacement. A guard rail that shades the walkway is part of the design problem, not a reason to remove the guard in service [14, 9].

For exterior installations, select the beam, mounting position, aim and shielding to keep useful light on the required work and routes while limiting spill onto neighbouring property and unnecessary upward light [3, 26]. Where exposed beams cause glare for nearby road users or workers, re-aim, shield or change the optic. Recheck that route edges and work detail remain visible from the required positions after the change.

Select the complete system for the actual supply, temperature, moisture, dust, vibration and hazardous-location conditions. Supply disturbances during machine operation and voltage drop along circuits can undermine otherwise suitable lighting. Obtain compatible driver and control data rather than treating a larger wattage as the remedy. These constraints narrow the feasible choices; they do not replace the optical design [14, 3].

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5.5 Control illuminance: choose the output and arrangement

Once the required lux level has been selected, choose how the fittings will deliver it. Lux describes light arriving at the assessed surface; lumens describe light output from the fitting. One lux is one lumen arriving per square metre. Multiplying the required average lux by the area therefore gives the lumens needed *on that surface*. The fittings must supply enough output to deliver that light after distribution and service losses [26].

For a reasonably regular room with a suitable array of fittings and matching utilisation data, the average lumen method gives a preliminary estimate:

$$\Phi_{\mathrm{total,initial}} \approx \frac{E_{\mathrm{m,avg}}\, A}{UF\, MF}. \tag{1}$$

Here, $\Phi_{\mathrm{total,initial}}$ is the total initial output of the complete fittings in lumens, $E_{\mathrm{m,avg}}$ is the required maintained average illuminance in lux, and A is the assessed area in square metres. This estimate concerns an *area average*, not the minimum at every point [26].

The **utilisation factor**, UF, describes how effectively the selected fitting and room deliver light to the assessment plane. Obtain it for the actual distribution, room proportions, mounting height above that plane and surface reflectances. Its basis must match *complete-fitting lumens*; a table based on bare-lamp lumens needs the corresponding calculation convention. Dimensions alone do not determine this factor.

The **maintenance factor**, MF, allows for the expected reduction in delivered light between maintenance interventions. Justify it from equipment data, contamination, ageing and the cleaning and replacement arrangements that can actually be sustained. Neither factor is a generic mine allowance, and neither corrects a blocked light path [26, 23].

Turn the estimate into a selection.

1. **Define the requirement.** Identify the selected lux value, its average or minimum basis, the surface and area, and the operating and maintained conditions. Use the reference for the actual task in Section 8.

2. **Establish the geometry.** Mark feasible mounting positions, height above the task plane, aiming and obstructions. Choose a distribution that covers the required surfaces. Greater height usually spreads the beam over a larger area; the useful coverage depends on the fitting's actual distribution.

3. **Predict the delivery.** Obtain matching manufacturer data. Use Equation 1 where its room and average-lighting assumptions apply. For irregular excavations, obstructed routes or upright tasks, obtain a calculation on the relevant surfaces using the proposed fittings and geometry.

4. **Choose the lumen package and quantity.** Divide the estimated total among candidate fittings and select available outputs and a practical arrangement. More lower-output fittings may distribute light differently from fewer higher-output fittings. Recalculate the proposed combination rather than choosing by total lumens alone.

5. **Confirm the arrangement before purchase.** Require the predicted average, relevant minima and uniformity on the specified surfaces. Resolve dark gaps, shadows and glare by changing the beam, positions, aiming or output. After installation, verify the same conditions using Section 9 [26, 16, 14].

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Light contributions add where they arrive. Illuminance from separate lights adds at the same point on the same surface. Two equal contributions double the lux there. Doubling fitting numbers doubles lux only where the added fittings provide an equal contribution; distance, direction and obstructions can make their contributions unequal. Increasing output in an unchanged arrangement also leaves its minimum-to-average uniformity unchanged. Appendix C.9 explains addition and output scaling [26, 27].

Specify the arrangement as well as the output. State the required lux and assessment basis; geometry and task planes; complete-fitting lumens at the selected setting; optic, quantity, positions and aiming; and maintenance assumptions. Request a calculated layout tied to those exact products and settings. Apply the equipment and installation constraints in Section 5.4. This makes the selection reviewable before equipment is bought; commissioning confirms its installed performance.

5.6 Control uniformity by filling the weak parts

Define the area needing consistent provision: an inspection surface, occupied work area or route. Deliberately different task and circulation levels are not necessarily poor design. An inadequately lit location within the assessed area and a disruptive transition between areas are different problems [15].

For minimum-to-average uniformity,

$$U_0 = \frac{E_{\min}}{E_{\text{avg}}}. \tag{2}$$

Both values must concern the same area, plane, lighting state and method. Retain the selected source's ratio and acceptance direction; other formulations exist. Resolve unclear wording rather than silently converting it into a mine-wide limit.

Worked example: the same average, different minima. Table 6 uses five invented values representing equal areas. Both distributions average 100 lx. They are arithmetic examples, not measurements or predictions from Figure 14.

Table 6: Illustrative distributions: raising all values does not change their minimum-to-average ratio.

Case	Representative values (lx)	Average (lx)	U_0
A	20, 60, 100, 140, 180	100	0.20
B	70, 90, 100, 110, 130	100	0.70
Twice A	40, 120, 200, 280, 360	200	0.20

Doubling A doubles its minimum and average, leaving their ratio unchanged. It can help an absolute illuminance requirement but does not repair the uneven pattern. Improving that pattern requires more contribution to the weak locations relative to the bright ones.

A gap between fittings calls for reduced spacing, more useful beam overlap or another fitting serving the gap. A dark edge may need the outer row moved towards the occupied edge or supplementary lighting. A shadow behind a conveyor needs a clear path on that side of the structure. Each intervention addresses a specific cause [15, 16, 2].

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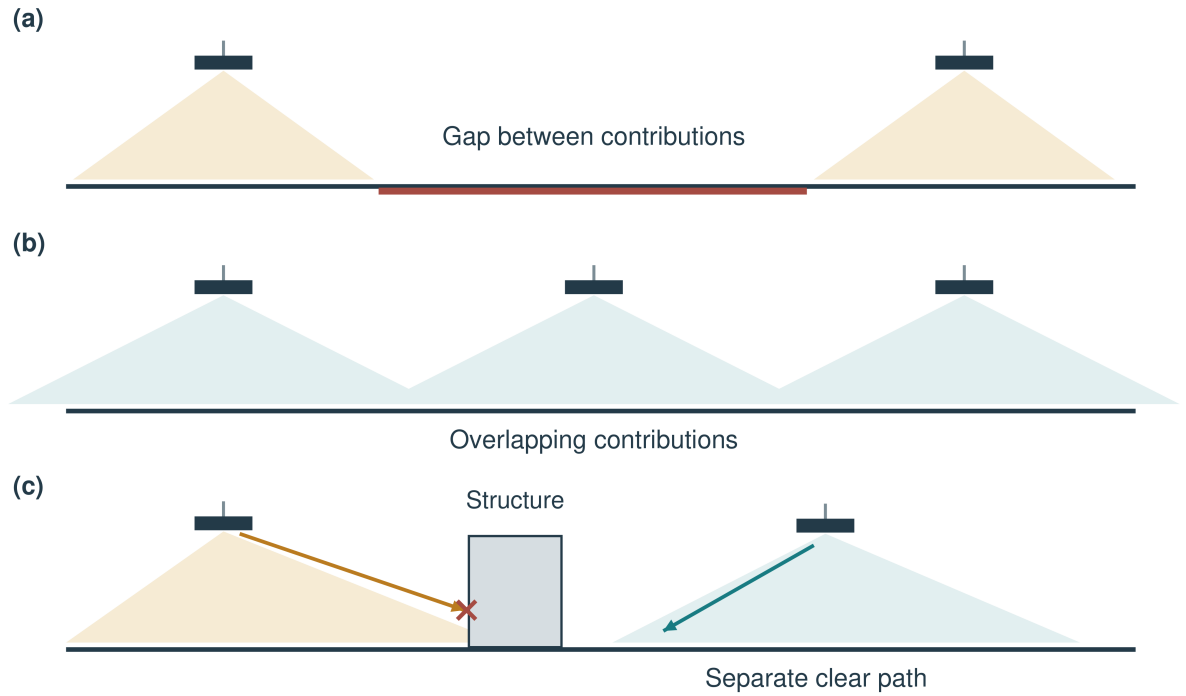


Figure 14: Closer or differently distributed contributions can address an open gap; a blocked region needs another clear path. Beam outlines are schematic and establish neither lux values nor a spacing rule.

Manufacturer spacing criteria can guide a preliminary regular layout. Use mounting

height above the assessed plane, not automatically above the floor. Usable spacing depends on the distribution and its stated conditions. Raising a fitting may broaden coverage and reduce relative spacing, but also increases distance and can reduce task illuminance. A wider beam can improve overlap while sending light towards workers. Recalculate the minimum and average after a change [26].

On the underground route, a small local light can serve a shaded floor patch. Demonstrate that its beam reaches the edge and obstruction through normal equipment positions, without exposing approaching workers to glare. Historical alternating rows are useful precedents; modern optics and the actual conveyor determine the result [2].

Treat transitions separately. Extend useful coverage through the approach to a darker area and avoid a bright source or local patch dominating the departure view. The next edge or obstruction should remain recognisable as the worker moves or looks towards it. Do not infer one adaptation waiting time or acceptable ratio for all transitions [15, 13].

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5.7 Control glare without losing useful task light

Illuminate the task and its surroundings sufficiently while limiting excessive brightness and unwanted light in the views people need for their work. A worker should be able to recognise the required detail without an exposed source or a reflection masking it [15, 23, 14].

Begin with the worker's task, position and viewing direction, including approaching people, helpers and operators looking up. Decide whether the problem is a directly visible source, a masking reflection, or both. The most useful remedy changes that light path while retaining the light needed on the task. [15, 14]

BEFORE **AFTER**



Figure 15: Outbuilding lighting before and after replacement of bulkhead lights and floodlights with downlights. The authority reports retained access lighting with less upward spill. Photographs: North York Moors National Park Authority (NYMNPA). [28]

These published photographs illustrate an intervention. Exposure and viewpoint are not controlled, and photographic starbursts do not quantify an observer's glare.

Combine controls where needed: reposition or aim a fitting, shield its bright face, reduce its emitting brightness, distribute light over suitable sources, or adjust output. Where surfaces are suitable, illuminate the surroundings to soften brightness differences. In a yard, assign each fitting a defined area and add appropriately positioned lighting where coverage remains inadequate. Avoid extending one fitting's reach until its bright face shines into occupied views. [15, 12, 3, 29, 14, 17]

Appendix D illustrates fitting choices, installed changes and their trade-offs.

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Choose the remedy for the view

Apply the control to the identified source or reflection, then confirm that the task and surrounding hazards remain visible.

Table 7: Practical glare controls: useful actions and arrangements to avoid.

Control	Do	Avoid
Position and aim	Move or aim the fitting so useful light reaches the task and less light reaches occupied eye positions. [15, 12, 14]	A bright fitting facing the route, or shifting glare from one worker to another.
Shield the source	Use suitable recesses, hoods, baffles or louvres to hide the emitting face from required views. [15, 23]	Assuming mounting height or a wire guard provides effective optical shielding.
Spread the light	Consider suitable lower-output fittings, larger emitting surfaces or well-placed strips. Give each fitting a defined area while maintaining task illuminance. [12, 3, 29, 14]	Replacing one glare source with a row of exposed bright points.
Diffuse or adjust output	Select compatible diffusion or optical control; adjust output to the task and verify the result. [29, 14, 30]	Unapproved covers or reducing output until footholds, cables or detail disappear.
Balance the surroundings	In suitable buildings, use well-lit matte surrounding surfaces or indirect light to soften brightness differences. [11, 3, 31]	Assuming that reflected-light schemes will work against dark underground surfaces.
Remove masking reflections	Move the light or task so the reflected image misses the detail; use suitable matte finishes where permitted. [15, 3]	Adding light along the same reflection path or altering protective windows without approval.

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After the change, confirm that people, markings, floor edges and obstructions remain recognisable from actual work and approach positions. Include upward views and normal equipment movement. A floor lux reading alone does not establish glare control. [15, 23, 14]

Lux describes light reaching a surface; luminance describes source brightness. Preserve task illuminance while controlling light towards the eye. More fittings, a larger source or a diffuser is not automatically glare-free. [3, 14]

Apply glare ratings within their method. Indoor UGR does not assess disability glare or universally rate machine lamps and adjustable floodlights. [23]

See Appendix D for photographic examples, components and limitations.

5.8 Make the required target distinguishable

Identify the information the worker is missing. An evenly lit component can merge with its background; a scale can be too small at the working distance; a person can be hidden by a machine. More general output helps only to the extent that it addresses the difficulty.

For a dark part on a dark bench, a suitable pale matte tray can increase its difference from the immediate background. A clear, durable marking can distinguish an edge or control where permitted. Avoid adding a glossy background that produces a reflection. More light can improve detection of existing contrast, especially at low levels, but evenly increasing light on two matte surfaces does not change their reflectance difference [13, 15].

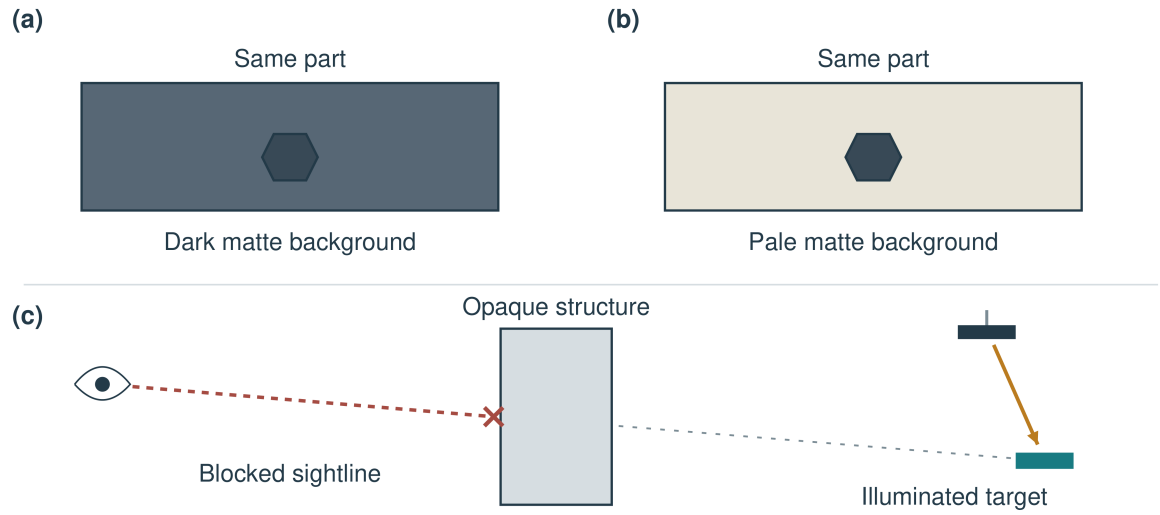


Figure 16: A different matte background can reveal a part; extra light cannot reveal a target through an opaque obstruction. These comparisons illustrate design choices, not measured detection performance.

If the gauge reflection is removed but its graduations remain too small, consider a permitted larger marking, suitable visual aid or safe change in the work/view arrangement. Do not move workers closer to moving equipment or remove guarding to improve visibility. Apparent detail size and the time available to recognise it belong in the task definition [13, 16].

On the underground route, light the surfaces that carry information: the walking surface and edge, the side of an obstruction and required upright markers. A horizontal floor criterion does not describe every upright target. If structure hides the target, brighter lamps cannot resolve the sightline. Change the permitted layout or viewing arrangement, or address the visibility hazard through a separately designed measure. Keep the issue unresolved until the solution is established [1, 14].

Surface and mobile work apply the same reasoning over changing views. Compare projected lighting from a few positions with distributed light closer to tasks. The latter can reduce shadows and long oblique paths but adds mounting and supply locations. Evaluate representative surfaces and atmospheric conditions; a favourable dry, clean, stationary view does not establish performance in the operating scene [16, 12]. Sections 6 and 7 develop these applications.

Describe the required functional achievement: reading the pointer against the correct graduation, distinguishing the fastener from the bench, or recognising the obstruction from

the specified approach. An impression that the area is brighter is too vague. Record the position, condition and uncertainty with the numerical result.

5.9 Control shadows and use direction to reveal detail

A shadow over the fastener needs light from a direction that the hand or tool does not block. Move the task lamp to a suitable side or add another clear contribution. Try the arrangement through the handling sequence; an empty bench does not reveal the operator's shadow [15, 3].

A broader source or diffuse fill can soften a shadow. Several distributed contributions can reduce a deep single-source shadow, but several small sources may produce multiple confusing shadows. Each extra lamp adds a possible glare or reflection path. Supply enough fill to reveal the detail while preserving useful shape information [15].

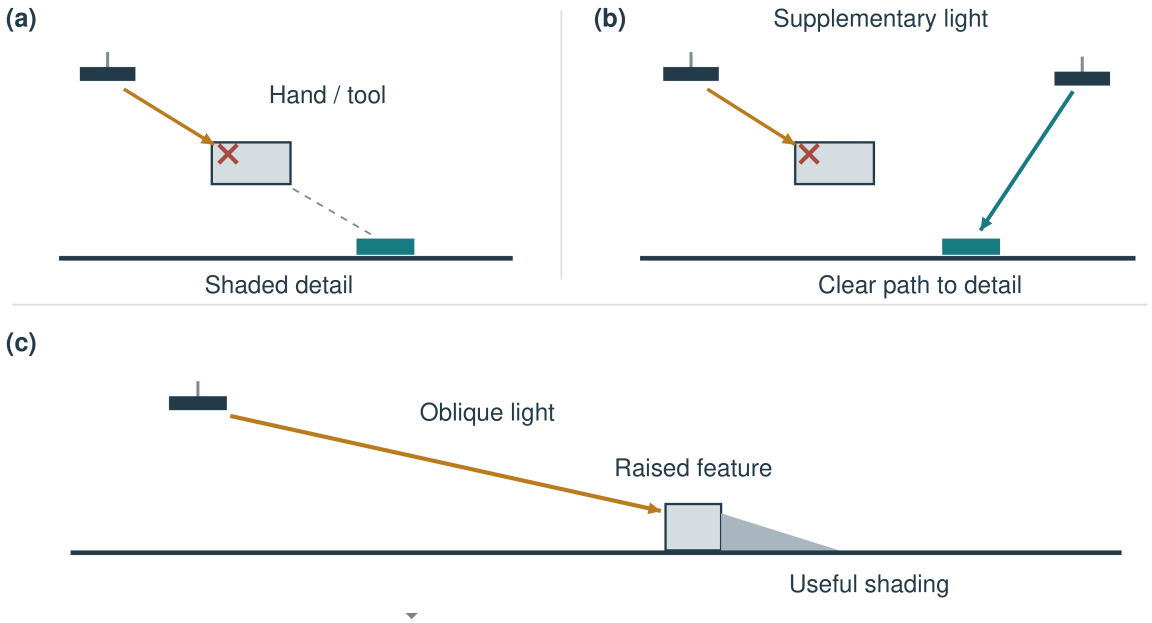


Figure 17: Top: a supplementary clear path reaches detail shaded by a hand or structure. Bottom: oblique light deliberately creates shading that reveals a raised feature. The geometry is conceptual; the useful arrangement depends on the material and task.

Inspection can have the opposite problem. Very diffuse light may reveal little relief on a raised feature or shallow irregularity. Directing some light obliquely across the surface can create highlights and shading that reveal it. For a polished component, a controlled reflected source pattern may reveal deformation. Try representative known features and sound surfaces from the intended view. The arrangement should reveal the feature without making ordinary reflections look like defects [15, 16, 3].

Underground, a lamp beyond a conveyor may light its structure while shading the walking side. A protected fitting with a clear path on the walking side is a more direct remedy than increasing the original source. Cover the required machine positions or provide suitable relocatable lighting; a solution for one parked position is incomplete [2, 14].

Reflective workshop surfaces can provide useful fill. Dark or contaminated underground surfaces may contribute much less, so do not assume that reflected light will fill a shadow. A suitable lighter finish can help where permitted, durable and maintainable, but cannot replace a clear light path. Evaluate the surface conditions expected in service [3, 2, 14].

The aim is to remove concealment while retaining information about form. A visible fastener with useful shading around its head is preferable to either a hidden fastener or an inspection surface whose detail is flattened by unsuitable lighting.

5.10 Choose colour rendering and appearance for the work

Specify colour rendering for the colours carrying information: cables, indicator states and identification marks. Compare manufacturer data with the relevant task criterion, then examine actual items under the proposed lighting. Colour appearance, usually described by correlated colour temperature, is a separate choice. A cool-looking lamp does not establish accurate colour recognition; the LED label describes neither property [15, 23].

Where colour discrimination is confined to a small area, suitable task lighting may serve it. Retain reliable recognition of safety colours and account for nearby coloured surfaces or other sources. This guide does not select one colour temperature or rendering index for every task.

5.11 Select controls that preserve the appearance of motion

For work around rotating or reciprocating machinery, obtain temporal-light-output information for the proposed lamp, driver and controls. Select a compatible combination with suitable performance throughout its operating and dimming range. A system that appears steady at full output can behave differently when dimmed. Absence of visible flicker does not establish that motion appears correctly [23].

Investigate apparent-motion anomalies through competent equipment assessment. An unspecified LED replacement or a quick visual check does not establish the cause or solution. Keep isolation and machine-safety arrangements independent of how stationary a moving part appears.

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5.12 Compare alternatives and define the installed result

Compare alternatives against the same tasks, views and maintenance condition. Among arrangements capable of meeting the performance and site obligations, compare power, operating hours, service access, damage exposure, replacement compatibility and whole-life cost. A lower cost or higher overall score cannot compensate for an unreadable gauge [14, 3].

Control inspection light and general coverage separately where this avoids unnecessary output. Provide route and task lighting on entry and during occupied work; specify return-of-supply and reduced-output states. Section 11 develops operation and energy use; Section 10 develops the maintenance programme supporting the design.

Treat loss of normal lighting separately: specify the light, supply, duration and verification needed for safe cessation, egress and emergency functions under the applicable arrangements. Normal-operation values do not define emergency lighting.

The handover must let another practitioner reproduce the arrangement: task/view drawing, criteria and conditions, exact fitting and optic, mounting and aiming, controls, calculations and maintenance assumptions. Record installation changes. A substitute fitting with equal wattage needs its own relevant performance and equipment-suitability assessment [3, 14].

State the result in three parts

- **Numerical conformity:** identify the criterion, area/plane, lighting state and method; state whether the measured or appropriately calculated result satisfies it.
- **Functional performance:** state whether the required information is distinguishable from the specified positions through the relevant work, including glare, reflections and obstructions.
- **Unresolved performance:** identify missing criteria, untested states and remaining visual failures. A satisfactory lux reading alone does not close them.

A conforming lux result with an unreadable gauge or concealed route edge requires further work. Record acceptance only for the assessed conditions. Section 9 explains assessment; repeat the relevant checks after a consequential change [14].

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6 APPLYING THE PRINCIPLES IN MINING WORKPLACES

The examples below give practical lighting responses for representative mining workplaces. Named source recommendations retain their original application; the combinations and mining adaptations are the project's synthesis. The intended visual results and corrective actions below are practical design guidance, not additional numerical acceptance limits. Use Section 9 for the assessment procedure. Published case studies and mine-reported practices are identified as such; other examples and diagrams are constructed applications, not measured installations. Use the numerical references and their conditions in Section 8 alongside this advice.

6.1 Cap lamps and supplementary underground lighting

Documented lighting arrangements. GAP 804 describes workers' caplamps as the only illumination typically available at the stope faces it examined. It also reports cap-lamp-only illumination in most stope travelling ways studied, with some additional installations broken or inoperative. These observations support examining personal-lighting dependence at such workplaces. They describe lighting in separately examined workplaces; they do not assign a lighting mode to the individual accident records discussed in Section 2.3 [2].

Why a bright spot can leave hazards difficult to see. Rock, mud or dust can give an obstacle and its surroundings a similar appearance, leaving little contrast to distinguish its edges. A source close to the eyes also changes the shape information available to the viewer. The Bureau of Mines investigation explains that the source–target–eye geometry of a helmet-mounted caplamp can hide useful shadow outlines from its wearer. The limitation is **reduced visibility of shadow cues**, not an absence of cast shadows. Its demonstrations show that light from a different direction can make floor hazards more conspicuous by revealing their shape [32].

A concentrated cap-lamp beam may illuminate the point being viewed while leaving nearby floor objects and movement to either side poorly illuminated. This restricts the **illuminated peripheral field**; it does not change the eye's anatomical field of vision. NIOSH compared conventional concentrated beams with a prototype distributing light towards floor and peripheral hazards and found improved detection under the tested conditions [33]. Figure 18 illustrates the change in distribution.

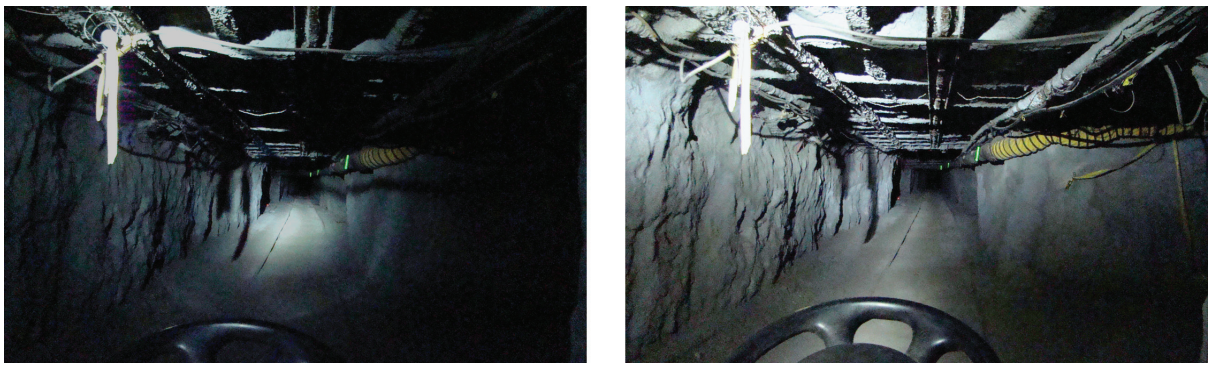


Figure 18: Conventional LED cap lamp (left) and NIOSH prototype with a redistributed beam (right). Both panels show cap-lamp arrangements, rather than personal lighting compared with supplementary area lighting. Photographs by NIOSH, reproduced unchanged from its cap-lamp bulletin [34].

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Fall-of-ground hazard identification. The MOSH *Improved Underground Workface Visibility* review focused on conventional stope faces because of their fall-of-ground injury and fatality burden. It considered supplementary workface illumination as a means of improving hazard identification where workers depended on cap lamps. The benefit evidence is observational and described as anecdotal; it does not establish a measured reduction in rockfall fatalities. Lighting supports recognition and examination alongside ground-control and making-safe measures [35]. Section 6.3 gives the existing workface arrangements and Eland photographs.

What the research contributes. Table 8 distinguishes the lighting comparisons from the workface observations. The findings support improving useful coverage and visibility for the actual task; they do not establish a universal beam angle, accident-reduction percentage or additional lux threshold.

Table 8: Lighting comparisons and findings relevant to cap-lamp-dependent workplaces.

What was examined	What was found
NIOSH: conventional concentrated cap-lamp beams and a prototype distributing light towards floor and peripheral hazards [33].	The prototype improved detection of floor objects and peripheral movement under the tested conditions.
NIOSH: machine lighting with and without auxiliary LED lighting; cap lamps were worn in both conditions [4].	Participants located floor-object sets faster with auxiliary lighting. This was not a cap-lamp-only versus area-lighting comparison.
Bureau of Mines: floor-hazard visibility with cap-lamp geometry and a different source position [32].	Changing the light direction revealed shadow outlines and made low-contrast floor hazards more conspicuous.
MOSH: visibility and supplementary lighting at conventional stope faces [35].	The review advocated improved workface lighting to support hazard identification; its benefit evidence was observational.

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Practical lighting response. Apply these responses to the task and worker's view, using the general, localised and task-lighting principles in Section 5:

- **Select useful coverage as well as a central spot.** Choose a cap-lamp distribution that reveals relevant floor and peripheral hazards while retaining the central task view. A bright central spot alone does not establish that nearby hazards are visible [33, 34].
- **Supplement personal lighting where important features remain difficult to identify.** Provide suitable fixed, portable or machine lighting for the face, working area and relevant approach. GAP 804 recommends task-appropriate caplamps and consideration of additional portable lights at the face; COL 451 recommends peripheral illumination for production-heading tasks. Match equipment and supply protection to the mine application [2, 8].
- **Use direction to reveal shape.** Position supplementary light away from the viewing axis where this makes surface relief and obstacle edges distinguishable. Retain useful shading, fill deep obscuring shadows from another direction, and aim or shield sources to avoid dazzling nearby workers. If an edge still merges with its background, change the

light direction or improve contrast rather than relying only on more output from the same position [32, 2].

- **Keep coverage with the work.** Relocate or extend lighting as the face or equipment position changes. Clean contaminated optics and restore failed fittings before their loss leaves the relevant task or route inadequately served. Check the result from worker positions using Section 9, and maintain it using Section 10 [2, 35].

6.2 Travel routes and changes in level

A route needs light on the walking surface and sufficient contrast to distinguish steps, obstructions and approaching activity. A practical response combines the fitting layout with the surfaces that the pedestrian sees.

Practical arrangement.

- **Distribute light along the route.** GAP 804 compares three tubular-fluorescent layouts and recommends two longitudinal rows with fittings alternating between opposite sides of the haulage. It reports better distribution than a single row, while warning that conveyor structures can still shade the walkway. Treat this as an arrangement to evaluate, not a universal rule for LED fittings: select their distribution and spacing from the actual photometric data [2]. Use the manufacturer's spacing-to-mounting-height guidance to set an initial layout, then reduce spacing or change the distribution where obstructions interrupt its coverage [17].
- **Keep the light path clear and improve useful reflected light.** Position fittings so that pipe ranges, ducting and conveyor steelwork do not intercept light intended for the walkway. Where practicable, use maintained light-coloured wall finishes to improve distribution; GAP 804 identifies whitewash or light-coloured shotcrete as underground options. Surface treatment supplements the lighting layout. Retain contrasting or reflective markings at restrictions and obstructions alongside the site's signs and traffic controls [2][8].
- **Reveal changes in level.** Position stair lighting so that the tread and riser remain distinguishable from the approach. Use contrasting step-edge finishes where appropriate; GAP 804 recommends this at chairlift landings and workshop platforms [3][2].

Transitions. A person entering a dark section from a bright waiting area may temporarily have difficulty seeing until their eyes adapt. This differs from disability glare, in which light reaching the eye reduces contrast, and from dark gaps caused by poor distribution. COL 451 describes extending and progressively reducing lighting on approaches and improving reflectance near section entrances. Where practicable, provide a gradual transition and let workers establish the visibility needed before moving on [8][13].

Intended result and corrective action. The route ahead, step edges and obstacles should remain distinguishable as the person approaches, including between fittings. If a step merges into the background, direct light across its tread and riser and improve edge contrast. If a pipe or conveyor casts a dark band across the walkway, move the fitting to the walkway side or add light from another direction. If the path alternates between bright pools and dark gaps, reduce spacing or use a broader distribution rather than increasing

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(a) Stope face, first view.



(b) Stope face, second view.



(c) Haulage.



(d) Centre gully.

Figure 19: Photographic examples of strip lighting at Eland mine: (a,b) stope faces; (c) haulage; (d) centre gully. Source: photographs reproduced from Minerals Council South Africa/MOSH, *Improved Underground Workface Visibility*; original photo credit: Eland Mine (2022) [35].

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the output of the same narrow beams. If an exposed fitting masks the route ahead, change its position, shielding or optic while retaining light on the walking surface. These responses apply the distribution, obstruction and glare guidance above; a satisfactory floor average alone does not resolve these faults [2][17].

6.3 Stopes, workfaces and travelling ways

In a conventional stope, provide distributed light along the face as well as the approach so that the hanging wall, work area and footing can be inspected without relying only on a narrow caplamp beam. In the MOSH Eland case study, a continuous strip followed the travelling way, gullies and face; the face strip was fixed behind the last line of permanent support and moved forward with mining. The study reported an even appearance and no observed glare at the visited panel. Use this as an example of a layout, not a standard mounting distance or proof that other panels will have the same result [35]. Figure 19 shows the Eland workface, haulage and centre-gully arrangements described in the case study.

Plan the power connection, extension, handling, removal before blasting and storage with the mine's competent electrical and production personnel. At Dishaba, shorter plug-connected sections replaced longer strips so that a damaged link could be replaced; the team nevertheless observed dark gaps at connectors. Keep the hanging-wall features, face markings and footing visible along the working length. Where connector gaps or a support

leave one of these targets in shadow, reposition the strip or add a separately directed approved light; raising output elsewhere does not remove that shadow. Retain replaceable approved components. The case study distinguishes intended use during entry examination from actual use after examination at Dishaba: establish a safe, approved way to illuminate the examination itself rather than assuming a strip can always be installed first [35].

Choose and install equipment for the mine's actual area classification, gas and dust hazards, electrical protection and approval conditions. Intrinsically safe and flameproof are different protection methods; neither may be assumed merely from lamp voltage or the presence of stone dust. At Matla, participants distinguished backbye installations from working sections and fuel or lubrication locations; they also reported that trialled strips were difficult to maintain in water, mud, dust and spray. Select protected, cleanable fittings and connections for those exposures, mount them clear of routine impact and water accumulation, and include relocation and cleaning in the work sequence. Where a strip repeatedly fails at exposed joints or cannot be kept serviceable, use a suitable enclosed fitting or a different connection arrangement instead of repeatedly replacing the same vulnerable installation.

Control brightness at eye level. Position the emitting surface outside the normal line of sight and direct its useful light towards the face and footing. MOSH recommends positioning the strip so it illuminates the face area without shining directly into workers' eyes [35]. If a bright strip masks detail on the darker rock, change its orientation or use a suitable approved shielding or optical arrangement; where adjustable output is provided, use a task setting that preserves the face detail and footing. A dimmer setting that makes the ground hazards disappear calls for better distribution or a separate ground light, as developed for machine work in Section 7.

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Surface reflectance. Light-coloured surfaces can return more of the incident light to the workplace, but their contribution falls when they become dirty. GAP 804 describes light-coloured shotcrete or whitewash in haulages; COL 451 discusses light-coloured stone dust and reflective brattice cloth [2][6]. During the Matla visit, participants described stone dust on roof, sides and floor for coal-dust explosion prevention and noted its white appearance and lighting benefit. Treat any visual benefit as secondary to the mine's approved explosion-prevention programme; do not change its material, application or maintenance for lighting without the responsible specialists' approval. Retain the lighting benefit by maintaining the approved light-coloured surfaces and cleaning contaminated lamp covers after dusting. A white wall can return useful light while dust on the fitting reduces the light reaching it.

Match the light to the stope activity. A broad view of the face and a clear view of a drill mark are different needs. GAP 804 identifies hanging-wall condition, misfires, drilling and charging, supports and barricades as critical visual information at the stopes it studied, and recommends task-appropriate caplamps with consideration of additional portable lights [2]. Table 9 translates those tasks and its gully observations into practical arrangements. These are project applications to be selected for the actual work, not layouts tested by the roof-bolter experiment. Their optical responses apply the source-position and shadow principles discussed earlier [14][3]. Lighting supports the mine's ground-control, explosives and signalling procedures.

The gully targets and need to avoid glare beside travelling ways come from GAP 804, which also recommends dedicated audible and visible signalling [2]. Keep signals distinguishable with the work lights on. A worker should be able to look from the winch area

Table 9: Stope activities, useful views and lighting responses.

Activity	What must remain visible	Arrangement and corrective action
Examination and making safe	Hanging-wall and face features, markings and the approach.	Supplement the caplamp with broad, directed workface light available for the examination. If a support or the inspector shades a feature, move the source laterally or add another direction from a permitted position.
Drilling	Hole mark, drill steel, alignment and nearby hands and footing.	Direct local light at the working interface while retaining surrounding coverage. If the drill or worker cuts off the beam, move the lamp to the unblocked side or provide a second direction.
Charging and misfire-related inspection	Hole locations, required markings, equipment and access.	Provide task light on the face detail within the mine's approved work sequence. If a wet surface masks a marking with a reflection, change the lamp–surface–eye angle while keeping the route lit.
Support installation	Roof contact, support members, tools and the assistant's work.	Illuminate the assembly and roof from positions clear of support shadows. If one worker's body hides the other's target, provide another light direction; a brighter beam from the same blocked position will not reach it.
Cleaning and sweeping	Floor relief, loose rock, cables and the route around the work.	Spread light across the floor and its immediate surroundings. Fill dark patches with a broader or separately directed source while retaining shading that reveals changes in level.
Gully and scraper work	Ropes, attachments, drum coiling, markers, signals and relevant personnel positions.	Provide surrounding light where the winch task requires awareness beyond the caplamp spot. Shield it from passing workers. A bend that blocks the driver's view needs the mine's dedicated signalling and interaction controls; extra light cannot restore that sightline.

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towards the darker route without an exposed lamp masking the route. Redirect or shield that lamp and retain light on the winch task. Select and relocate face lighting so that these useful views survive the advance of work, as described next.

6.4 A changing development workplace

An advancing workplace needs an arrangement that can follow the inspection or preparation task while retaining light on the approach. Figure 20 shows why an operating lamp can cease to serve the current face.

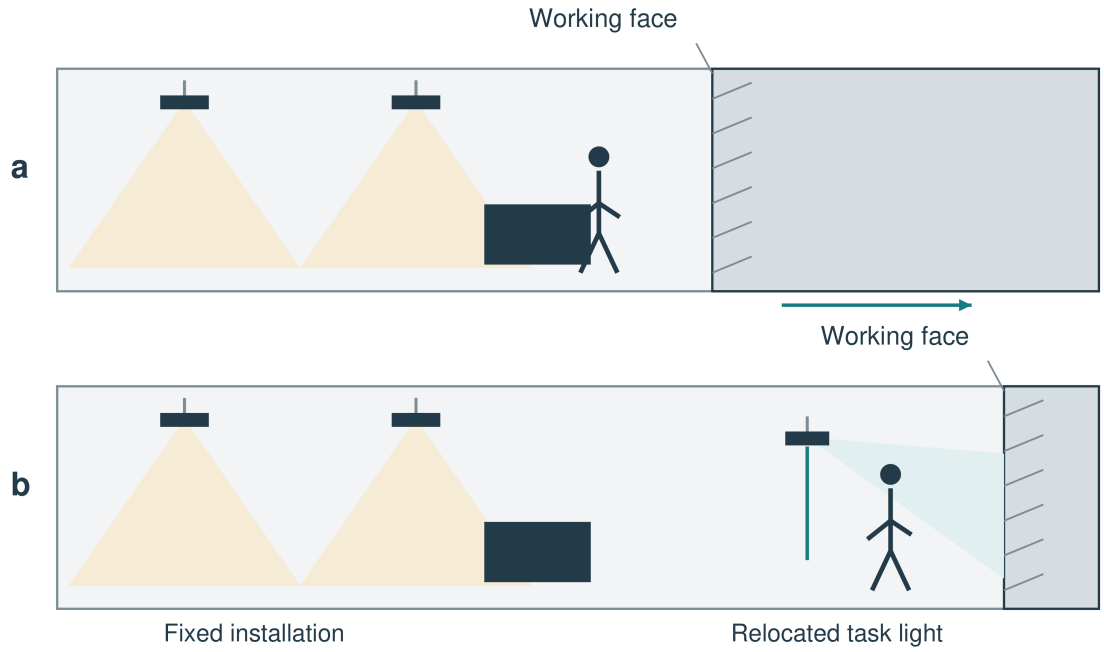


Figure 20: As the face advances, move or supplement the task light so its beam reaches the current work while lighting remains on the approach. The same lamp output at the old position can leave the new face in shadow.

Practical arrangement.

- **Provide portable area lighting where fixed coverage cannot follow the work.** For production-heading inspection and preparation, COL 451 recommends portable flame-proof units providing peripheral illumination and advises against narrow spotlights for that purpose. A bright central beam alone leaves the worker's surroundings poorly served. Retain the coal-specific protection context when selecting equipment for the actual hazardous location and supply; an ordinary rechargeable lamp is not an equivalent specification [8].
- **Set the light for the current face and worker position.** Place and aim the area light to reach the inspection or preparation surfaces without shining into another worker's or approaching operator's view. Keep it clear of obstructions. GAP 804 also recommends portable lighting where permanent production-area lighting is impractical, with useful surrounding coverage and control of interference with other workers' vision [2].
- **Plan relocation as part of the work sequence.** As a project application of this advice, identify where the unit will stand, which task surfaces and approach it will serve, how its

supply will reach it, and when it must move as development advances. Use the mounting, protection and service-integration provisions in Section 5; relocating a fitting should leave both the new task and its access route served.

Intended result and corrective action. The inspection surface and the route to it should be visible from the working position, including when the worker and tools occupy the space. A lamp that lights only the old face or approach needs moving or supplementing. If the worker's head or a drill boom casts a shadow over the inspection surface, move the source laterally or add a second direction of light. If the source shines towards another crew member, shield or redirect it so light still reaches the target. Establish the new lighting position as part of advancing the workplace, before the next task depends on that coverage [8][2].

6.5 Longwall faces and transfer points

Provide light along the route people actually use, as well as on the face tasks, support controls and transfer interfaces. Supports, services and equipment interrupt the beam, and their movement changes the shadow pattern. Use distributed fittings positioned to reach the walking surface and controls through the relevant support positions. If a support creates a dark interruption, relocate or supplement the source so the next foothold and required control remain visible; increasing output on the visible side does not illuminate behind the support. The USBM handbook identifies adaptation problems at failed sections and distinguishes the actual travelways, face-support area, conveyor ends and control centre [13][14].

Treat the head and tail arrangements separately from the repeating face installation. Direct local light onto the transfer interface, access and controls, clear of structural shadows and the normal viewing direction. If equipment or a ventilation curtain hides a target, identify whether the light path or the worker's view is blocked and apply the appropriate lighting or operating response; retain the ventilation arrangement. These are project applications of the handbook's separate-zone examples, not adoption of its historical shadow exemptions. Provide accessible, protected fittings and cable allowance for moving supports. Where the remote end repeatedly dims or fails, investigate the supply and circuit losses as well as individual lamps [14]. Section 10 addresses restoration of failed coverage.

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6.6 Surface loading and tipping areas

Lighting needs to reach the occupied loading or tipping interface, the working boundary and the approach while keeping useful views from the cab and nearby work positions.

Practical arrangement.

- **Keep vehicles from blocking the principal light.** For vehicle bays, HSE recommends placing lights over the spaces between bays, where a tall parked vehicle is less likely to block them. It also recommends aiming lights so a reversing driver is not dazzled directly or through mirrors [36]. These are workplace-transport recommendations; their application to an open mine loading or tipping layout needs the actual vehicle positions and directions of approach.
- **Match the lighting direction to the surface.** HSG38 recommends overhead lighting that limits shadows where vehicles obstruct horizontal work surfaces; floodlighting can serve

vertical surfaces where obstruction is slight, with glare controlled [17]. For an open mining interface, the project application is to select positions and beam directions that reach the active edge or receiving face with the truck or loader in place. Where one position leaves the task shaded, evaluate an additional direction of light rather than simply increasing that fitting's output [3].

- **Supplement the active work area without overlighting the entire site.** Provide the background lighting needed for movement, then add localised lighting at the occupied handling or checking position. SLL recommends this combination where detailed exterior work is confined to limited parts of a site. Its loading-area advice also emphasises vehicle shadows and glare to drivers, including those looking upward [3].
- **Protect fittings at the material interface.** GAP 804 reports damaged lights at underground tips and recommends protective covers and prompt repairs. For surface installations, apply that protection principle to the actual impact, spillage and debris exposure, keeping covers and mounting structures clear of the required beam [2]. Section 10 covers inspection and restoration.

Intended result and corrective action. The operator should be able to distinguish the receiving edge, vehicle clearances and relevant ground or people with the vehicle and load in their normal positions. If the truck blocks the principal light, relocate the source or add a direction of light that reaches behind the obstruction. If a floodlight dazzles the driver directly or in a mirror, move or aim it away from that viewing direction; retain local light on the loading or tipping interface. If airborne dust masks the edge, improve dust control and source placement rather than relying on extra output through the same dust cloud. Where the cab, load or machine structure physically blocks the target, use the mine's visibility and traffic controls for that blind area; illumination cannot make the structure transparent [36][3][8].

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6.7 A conveyor with access, inspection and controls

A conveyor installation needs route lighting, light at inspection points and light on upright information surfaces. Figure 21 separates these needs so that one set of walkway readings is not used to represent every task. Figure 22 shows two South Deep walkway arrangements with lighting extending along the belt.

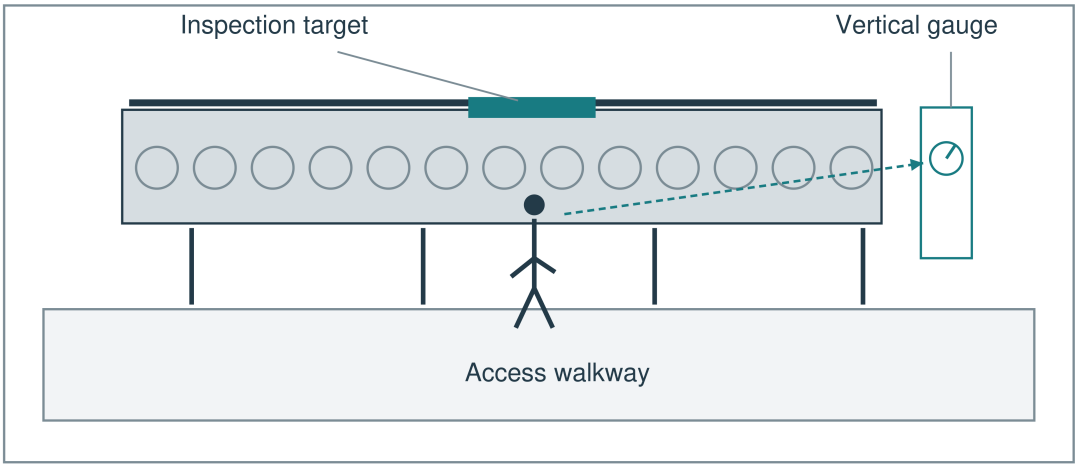


Figure 21: Conceptual separation of access, inspection and an upright information surface at a conveyor. Each task has its own relevant surface and viewpoint; the drawing is not a measurement layout or equipment-operating instruction.



Figure 22: South Deep conveyor walkways: floor-level access beside the belt (left) and a raised grated walkway (right), with lighting extending along each route. Project photographs: CoE 230702 site collection, South Deep.

Practical arrangement.

- **Light the walkway on its accessible side of obstructions.** Arrange fittings so belt structure and services do not leave the walking surface in a continuous shadow. At transfer points, COL 451 also recommends light-coloured framework and crossing platforms, dust control and cleaning to retain contrast. These measures help the worker distinguish the structure and access surfaces; adding light alone does not remove airborne obscuration [2][8].
- **Put additional light at the inspection task.** Use localised fittings for fixed inspection positions or an adjustable supplementary light for changing detail, retaining route lighting. SLL treats local lighting as a supplement to general or localised lighting. For relocatable

feeder breakers specifically, COL 451 recommends structure-mounted light sources and considers adjustable arms for the different operating and maintenance tasks. Recheck that arrangement after a move rather than assuming identical surrounding geometry [3][8].

- **Move the reflection away from the information.** For a glass-fronted gauge, apply SLL's control-room advice to the local lamp–gauge–eye geometry: move or aim the fitting so its bright image falls outside the part that must be read from the normal viewing position. Where repositioning is constrained, evaluate a fitting with lower brightness in that direction or suitable shielding. This is a project transfer of display-lighting advice, not a conveyor-specific source requirement [3].

Intended result and corrective action. The walkway should remain visible beside the conveyor, and the required gauge markings or component detail should be readable from the normal working position. If the worker's body or a guard shades the component, move the local light to an unobstructed side or provide a second direction of light. If a bright lamp image covers the gauge scale, move or aim the fitting until the image lies outside the reading area; adding output in the same position can make the reflection worse. If the task light shines into the walkway, fit suitable shielding or redirect the beam onto the component. Retain route lighting when local task lighting is switched off [3].

6.8 Workshop repair and detailed inspection

Overhead lighting can serve movement and bench work while leaving the underside of a vehicle or the inside of a machine enclosure dark. Figures 12 and 13 illustrate how general, localised and supplementary task lighting can serve different visual needs.

Practical arrangement.

- **Bring light below the obstruction.** GAP 804 recommends adding wall-mounted lighting to roof lighting and reports improved distribution beneath vehicles with vertical wall-mounted fluorescent tubes. It also identifies lighting beneath ramps and within inspection pits, and more effective use of portable units. Evaluate the same functions with the selected modern fittings, positioning and protecting them for the actual work and checking the glare introduced by low-level light [2].

- **Provide an adjustable task light for enclosed or changing work.** Locate it so the worker's head, hands, tools or an open cover do not intercept the useful beam. Retain background lighting for the surrounding work and access area. SLL recommends local lighting as a supplement and identifies distributed sources, broad distributions, reflective surroundings and local light as ways to reduce unwanted shadows [3].

- **Choose the direction for the detail being inspected.** For surface unevenness, try light arriving at a shallow angle across the surface so relief creates visible shading. For blemishes on polished surfaces, evaluate the reflection of a large luminous area. Keep unwanted source reflections away from ordinary markings, while recognising that some inspection methods deliberately use reflected light to reveal the defect. SLL illustrates these different arrangements in Figure 10.6; they are alternatives selected for the inspection task, not one universal direction for all defects [3].

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Intended result and corrective action. The required fastener, marking or defect should be distinguishable with the worker's hands and tools in the normal position, without forcing the worker to lean into a different view. If hands or an open cover shade the detail, move the local lamp to the other side or use another source direction. If a polished surface produces a masking highlight, change the lamp–surface–eye angle; for deliberate reflection-based inspection, use the source shape and direction suited to that defect. If the underside of a vehicle remains dark, add protected light below the obstruction rather than increasing roof-light output [2][3].

6.9 Applying the approach to an unlisted task

Name the detail that must be seen and the condition that hides it. For an obstructed beam, move or supplement the source; for a masking reflection, change its direction relative to the surface and eye; for a dark surrounding route, extend background coverage; for a blocked sightline, use a visibility or operating-control response. The preceding examples provide source-based starting arrangements. Apply the numerical reference for the actual task and surface using Section 8, without inventing a value where the evidence remains unresolved.

Control rooms, orepass/chute interfaces and processing-plant access are candidates for further worked guidance. Useful starting passages are SLL's control-room and integrated-plant advice and GAP 804's orepass recommendations. They are flagged for subsequent development rather than treated as fully specified applications here [3][2].

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7 LIGHTING MOBILE MINING EQUIPMENT

A machine needs different lighting for travel, its working task, cab information and access. Provide each function where it is needed, so that a bright travel beam does not have to serve every activity. The following arrangements combine mining-source recommendations with project applications. Their visual outcomes guide design and correction; numerical assessment follows Sections 8 and 9. COL 451 and GAP 804 use the operator's tasks and critical visual information to organise their machine advice [8][2].

7.1 Match the lighting to the machine's movement

Provide light on the route ahead, the ground close to the machine, the working attachment and access points as distinct functions. Size and position the beams for the actual bucket, boom, load and articulation range. SIM 160701 recommends unobstructed beams over the range of component movement and beam spread covering the visual target area; ISO 12509 distinguishes travel, work and reversing lamp functions [9][37].

A target can be dark because the beam misses it, or unseen because the machine blocks the operator's view. Correct the first by relocating, aiming or supplementing the light. Correct the second through suitable viewing aids, an OEM design response or the mine's controls for blind areas. GAP 804 identifies both beam obstruction by the LHD bucket and structural sightline limitations; these need different remedies [2].

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7.2 Travel and manoeuvring

- **Keep the travel beam clear of the load.** Position lamps so the bucket, load or attachment does not cut off the beam during the permitted travel configuration. For the LHDs it studied, GAP 804 recommends extendible or adjustable brackets where fixed positions are obstructed. Use an engineered mounting that locks securely and retains the machine's protection and clearance arrangements [2][9].

- **Fill the near field and turning side.** Where a narrow beam produces a bright distant patch but leaves the road edge, close ground or side clearance dark, select a broader distribution or add a separately directed near-field light. Increasing the output of the narrow beam leaves the coverage problem. COL 451 identifies restricted shuttlecar beams and limited peripheral coverage; SIM 160701 recommends increasing beam spread to serve the full visual target area [8][9].

- **Keep the source out of opposing views.** Use lamp position, a suitable optic, diffuser or shield to reduce direct light towards an approaching operator or worker. The useful result is an illuminated route with the edge and obstacles still distinguishable when the other lights are on. If aiming a lamp down removes distant coverage, change its optic or mounting, or provide a separate near-field source; do not exchange glare for an unlit route [9][14].

For a machine that travels in either direction, provide the corresponding route coverage in both directions and retain the OEM and mine's approved directional lighting and signals. A lamp arrangement that serves forward travel while leaving the reverse route dark requires a reverse-lighting response, not a higher forward setting [9].

Figure 23 shows a real continuous-miner scene under two lighting arrangements. The photographs make the difference in surrounding coverage visible; the source study, rather than the camera image, supplies the performance evidence.



(a) Standard lighting (b) NIOSH LED lighting

Figure 23: Continuous-miner scene with standard lighting (left) and NIOSH LED lighting (right). Original photographic panels from Sammarco's overview [38].

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7.3 Light the work where the attachment operates

Direct work lights onto the drill mark and rock interface, bucket edge, receiving hopper or other working target. Locate them outside the shadow cast by the attachment and use secure adjustable mountings where the task position changes. For face-drilling machines, GAP 804 specifically recommends separated forward floodlights in preference to spotlights to cover boom movement and reduce shadows. This gives a practical starting arrangement for a drilling machine with moving booms [2][9].

The working target should remain visible through the relevant attachment positions. If a boom cuts across one beam, move that lamp or provide light from the other side. If the roof is bright but controls or floor hazards remain dark, provide separate light to those surfaces. Keep exposed sources out of the operator's and helper's principal sightlines; the USBM handbook illustrates how source position and shielding alter this problem [14].



Figure 24: Researcher at a machine-mounted luminaire near the front roof-support structure of a roof bolter. The photograph shows the physical mounting context and scale; source: NIOSH, *Mining Topic: Illumination* [39].

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7.4 Worked example: a roof bolter

A bolter operator needs to follow the roof mark and drill assembly while an assistant handles bolts or attends the cable and hose. Give each position useful light throughout the work sequence. COL 451 identifies these targets together with machine clearances, controls, personnel at the corners and floor hazards. It recommends work floodlights directed to the roof and rig and to the machine top and sides, with adjustable mountings that remain secure in use [8].

1. **Approach and set up.** Place the travel beams so they reach around the rig and show the route and side clearances. Retain light at the cable handler's position. If a stored cable coil blocks the rear beam, change the approved storage or lamp arrangement; a brighter forward beam does not reveal the rear cable.

2. **Drill and insert the bolt.** Direct work light onto the roof mark, drill or bolt alignment and relevant working parts. Provide another direction where the boom, canopy or the operator interrupts the beam. Keep the illuminated detail visible when the worker looks up without turning the head; a caplamp beam tied to head movement may not serve a constrained posture [13].

3. **Serve the assistant and walking operator.** Light bolt storage, deck or floor footing and the relevant hand-working area separately from the roof target. For a walking control position, COL 451 recommends downward light below the controls. Aim it onto the floor and work area without exposing the bright source to the worker's normal view. Place fittings and cables clear of tool storage and impact-prone deck positions [8][14].

4. **Move away and reset.** Provide the required reverse-route coverage and retain useful rear and side task light for people in permitted positions. If a rear lamp dazzles the

cable handler, change its distribution, position or mode arrangement through the approved equipment process. Preserve the needed ground and cable illumination and the machine's established warning functions [8].

The intended result is a recognisable roof mark and alignment, visible controls and footing, and useful views for both operator and assistant through the relevant rig positions. A bright roof with a dark deck requires separate deck light; a visible lamp with an obscured worker requires a lighting or sightline response appropriate to the cause. The following study illustrates why output alone cannot select the arrangement.

What the Saturn study demonstrates. A 30-person roof-bolter laboratory study compared the existing compact fluorescent arrangement with a Saturn LED area luminaire at 100%, 75% and 50% output. At the front position, all Saturn settings reduced glare relative to the existing lights, and 50% gave the least disability glare and highest calculated visibility among the tested settings. The middle-position differences were not significant. The intervention combined controlled optics, placement and output: more output was not the best result at the front position. The researchers produced the reduced outputs with neutral-density filters, so this was not a trial of operator dimming controls [30].



Figure 25: Roof-bolter front and internal walkway under existing lighting (left column) and Saturn LED lighting (right column). Photographs by J.H. Fletcher & Co.; reproduced from NIOSH Technology News 560 [40]. These panels illustrate the arrangements; the reduced-output findings are established by the experiment described in the text.

Use adjustable output to serve the task. Where suitable approved equipment is available, provide separate adjustment of work lighting instead of forcing the worker to use full output in every setting. SIM 160701 proposes different settings for working and travelling in

already illuminated haulages [9]. As a project application, establish task-specific presets and a permitted adjustment range: the work detail, controls, footing and relevant surrounding targets must remain distinguishable at the lower setting, while the higher setting must not mask them through glare. If lowering output removes glare but also loses a floor hazard, improve the optic or provide separate floor lighting. If one setting cannot serve both the bright task and dark surroundings, separate their lighting functions. The Saturn 50% result supplies a reason to provide and evaluate adjustment, not a universal setting.

7.5 Make nearby workers visible to the operator

Provide useful light and contrast at the positions in which people can legitimately be present during the work cycle. For the LHDs studied in GAP 804, these include the front and rear, the sides of the bucket and the pivot region. A visible caplamp alone does not reveal the person's body, position or the ground around them [2].

If a person is within the sightline but disappears against a dark background, improve illumination of that position and maintain the site's high-visibility clothing and reflective elements. If an exposed lamp or reflection masks the person, redirect or shield that source. If the bucket, cab or bodywork hides the position completely, treat it as a blind area and apply the mine's separation, viewing-aid and operating controls; extra lamp output cannot restore that sightline [8][2].

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7.6 Show the machine's extent without dazzling workers

Locate approved position lights, reflectors or markings so that the front, rear, width and relevant projections can be recognised. SIM 160701 recommends lamps at the edges or corners where practicable and reflective measures where the machine design prevents this. Seeing a central bright point should not be the only cue to the width of a large machine [9].

Develop a marking layout for each equipment type and configuration, and apply it consistently to equivalent machines. Choose positions protected from impact and abrasion and, where practicable, have the original equipment manufacturer incorporate protected locations for reflective strips [9]. From the relevant approach positions, check that the available headlamp or caplamp reveals the machine's width, height and projections: reflective markings need light from the viewer's direction. Include the strips in pre-use and maintenance checks; clean obscured material and replace damaged or ineffective strips. Avoid relying on bucket or scoop markings where working wear rapidly removes them [9].

Where a work light faces a pedestrian route, redirect useful light onto the work or fit suitable shielding so the worker can still see the route and machine outline. Keep the mine's established signal meanings: an illuminated region or coloured machine lamp does not confer permission to enter the operating space.

7.7 Readable controls and a usable outside view

Provide self-lit instruments or suitably shielded local lighting so the operator can read the required labels and indications without directing a caplamp onto the panel. SIM 160701 recommends self-illuminating information displays and dials. Direct local light onto the controls rather than across the windscreen [9].

- **If the panel is reflected in the windscreen,** reduce unnecessary panel or cab-light brightness and change the source position or shielding to remove the reflected image from the outside view.

- **If a label remains unreadable at the setting needed for the outside view,** illuminate that label locally or improve its contrast rather than brightening the whole cab.
- **If incoming light reflects from glossy cab surfaces,** use OEM-compatible matte finishes and source control. COL 451, GAP 804 and SIM 160701 recommend matte cab interiors; do not cover instruments, essential markings or glazing [8][2][9].

Provide independent adjustment of display or local cab lighting where compatible with the machine. The useful setting permits reading the controls and then recognising the relevant outside targets when attention returns to the darker scene. Bright-to-dark adaptation is part of this problem, alongside glare and reflections; a cab-floor lux value cannot describe that outcome [13][3].

Matla personnel reported complaints about bright tractor LEDs and a sensing/dimming response when another light was detected. This is a mine-reported example of responding to opposing glare. For any automatic implementation, retain the task-specific minimum preset, a usable manual control and a defined safe output after sensor failure; design the response so an approaching light does not cause the route to become unlit. Section 11 discusses controls in more detail.

7.8 Illuminate the whole access sequence

Provide area light on the ground below the first step, the steps or rungs, handholds, landing and cab entrance. It should be available before boarding and remain useful when a person turns their head or faces the ladder during descent. A personal lamp supplies local detail but its moving beam should not be the only light on the next foothold.

In a field study on two haul trucks and two wheel loaders, area lights were positioned near the cab door or handrail and aimed to avoid shadows from rails and decks; an additional deck position was used on the larger loader. The area lights with a headlamp covered a broader region than the headlamp alone, while glare differed between the two tested luminaires [41].

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(a) CAT 980C loader access (b) Komatsu HD785 walkaround

Figure 26: Actual night-time field-study arrangements showing light on the access area and ground around mobile equipment. Source: Mayton et al. [41]. The tripods and temporary mounting arrangements belong to the study setup.

Use that layout principle with production-suitable fittings and mounts. If a rail or deck edge shades the first step, move the light to the exposed side or add a lower or intermediate source. If the ladder is visible but the ground beneath it remains dark, direct light to that

ground-to-step transition. If the source shines into a descending person's eyes, shield or reposition it while retaining tread illumination. Supply walkaround and inspection points from the relevant sides of the machine; one cab light will not reach through the machine to the rear [41].



Figure 27: Ground beside equipment (left column) and the upper access platform (right column), with area lighting plus a headlamp (top row) and a headlamp alone (bottom row). The photographs illustrate the surrounding coverage provided by area lighting. Source: Mayton et al. [41].

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7.9 Restore useful coverage when performance deteriorates

Where dirt or stone dust reduces the beam, clean the lens or cover using the approved method. Where coverage has shifted, restore the specified aim and secure the mounting; a new, brighter lamp does not repair a loose bracket. Replace damaged covers and failed lamps with the specified optical type, since a different beam pattern can create glare or leave a dark area despite a similar lumen rating.

Protect fittings and connections from impact and vibration while keeping the beam opening clear and the cover accessible for cleaning. If a recess or guard clips the useful beam, change the protection or mounting arrangement through the approved equipment process. GAP 804, SIM 160701 and the USBM handbook describe these protection and access needs [2][9][14]. Section 10 gives the maintenance and restoration procedure.

7.10 Further coal-machine applications

Use the same separation of task, surrounding and travel lighting for other coal machines. Table 10 gives concise project applications of the USBM handbook's machine examples and glare/protection advice [14]. Its historical equipment boundaries and exemptions are not adopted here. Longwall workplace arrangements are addressed in Section 6.5.

Table 10: Applying the lighting lessons to other coal-machine situations.

Situation	Useful arrangement and response to a poor view
Continuous miner or loader	Direct task light onto the face and gathering or loading interface, with separate surrounding coverage. Protect fittings from material sliding off a raised boom. If a rear source masks the receiving shuttle-car operator's view, reposition or control that source while retaining light on the transfer task.
Remote-controlled miner	Serve the permitted range of operator positions. If a lamp becomes glaring as the operator moves, alter its optic, position or suitable shielding across that range. Retain visibility of the trailing cable and floor; completely blocking a troublesome lamp can remove that useful coverage.
Shuttle car, scoop or LHD	Provide route and loading-interface coverage for the relevant travel directions, using actual canopies, sideboards and load positions. If a beam is cut off or a near-side clearance remains dark, relocate or supplement it. Control glare towards face crews without leaving the machine's required route unlit.
Low-seam work	Put useful light on the task independently of restricted head movement. Select a fitting profile and protected position clear of habitual crouched sightlines. If the nearby source masks detail, change its geometry or distribution; a higher-output replacement in the same position can worsen the view.

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8 RECOMMENDED ILLUMINANCE VALUES FOR MINING WORKPLACES

This section gives 69 selected references for defined workplace activities, normal lighting, equipment tests and emergency functions. Relevant South African mining guidance and task standards provide the numerical baselines; a stated mining adaptation is used where the source task or assessment method needs a project application. Appendix B records the selection and measurement decisions. Appendix A retains the published comparisons.

8.1 Reading the reference values

Unless a strict greater-than sign is shown, meet or exceed the stated reference on its specified basis. An **average** applies over the defined task area in its maintained condition. A **minimum** is the adopted lower limit at the specified assessment positions in service; bright readings elsewhere do not compensate for a deficient position. **Background** provision is measured without caplamps. Equipment tests and emergency criteria retain their own directions, lighting states and acceptance rules. H means horizontal. Apply a task value at the actual surface being used, rather than throughout the whole excavation.

Click the bracketed source number beside an application to open its published evidence in Appendix A. The W1–W8 headings open the corresponding workplace family.

The **Note** column highlights special lighting needs. **Colour rendering index** (R_a) describes colour rendering and is an index, not a percentage. Uniformity compares the minimum illuminance with the average or maximum over the same assessment area; a larger minimum-to-average ratio means fewer dark patches. Glare advice is expressed as practical action. The supporting decision records retain the source's numerical glare criteria.

For dedicated pedestrian and stope travel routes, the 5 lx background reference applies to that named function. Use the appropriate 20 lx category on portions that are also haulages, access crosscuts, shaft ladderways or inclined-shaft walkways. Local detailed tasks retain their own references. A satisfactory lux measurement alone does not establish that all hazards are visible; keep sightlines, contrast, shadows and glare suitable for the actual activity.

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Table 11: Selected illuminance references and special lighting notes. Values are in lux; the stated minimum, average or test basis forms part of each reference.

Workplace or application	Reference (lx)	Note
W1 – Access and pedestrian movement		
Interior pedestrian corridors [11] Ordinary pedestrian circulation in surface/support buildings.	100 average	
Interior stairs and changes of level [11] Steps and landings in surface/support buildings.	150 average	
Covered walkways in mine surface buildings [11]	50 average	Ensure safety colours remain recognisable.
Outdoor industrial-yard pedestrian paths [12]	5 average	Minimum/average uniformity $\geq$0.25; minimum/maximum $\geq$0.10. Limit glare to pedestrians.

Continued on next page

Workplace or application	Reference (lx)	Note
Underground shaft ladderways [10]	20 minimum	
Underground man-riding shaft conveyances [10]	20 minimum	
Underground inclined shafts and ramps with walkways [10]	20 minimum	
Underground haulages [10]	20 minimum	
Underground access crosscuts [10]	20 minimum	
Underground chairlift routes [10]	20 minimum	
Underground ventilation doors [10]	50 minimum	
Designated underground pedestrian walkways - background lighting [2]	5 background minimum	Protect fittings exposed to damage; reduce abrupt changes between bright and dark sections.
Dedicated stope access and travelling ways - background lighting [2]	5 background minimum	Protect fittings exposed to damage; reduce abrupt changes between bright and dark sections.
W2 – Transport and mobile-equipment interaction		
Outdoor industrial-yard slow vehicle areas [12]	10 average	Vehicle category up to 10 km/h. Minimum/average uniformity $\geq$0.40; minimum/maximum $\geq$0.20. Minimise driver glare.
Outdoor industrial-yard regular vehicle areas [12]	20 average	Vehicle category up to 40 km/h. Minimum/average uniformity $\geq$0.40; minimum/maximum $\geq$0.20. Minimise driver glare.
Interior loading ramps and bays [11]	150 average	
Underground shaft stations and sub-banks [10]	160 minimum	
Underground chairlift boarding and alighting [10]	50 minimum	
Mobile equipment - travel-direction light-output test [9] Vertical readings at 1 m above floor, 20 m ahead.	$>$ 10 directional test	Equipment lights only. Check all three points 20 m ahead in each direction of travel; also verify near-field coverage and person visibility.
Mobile-machine working and person-interaction surfaces [9]	50 minimum	Light actual work and interaction targets; eliminate obscuring shadows and minimise glare. Use the separate higher reference for detailed tasks.

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Workplace or application	Reference (lx)	Note
W3 – Extraction, development and construction		
Coarse face cleaning and material handling [11] Coarse manual handling and placement of large material.	200 average	Use local lighting where obstruction or task detail requires it.
Ordinary face marking, drill and boom positioning [23] Ordinary visible marks, collar positions and drill/boom clearances.	200 average	Colour rendering index $R_a \geq$80; minimum/average uniformity $\geq$0.60. Light the actual mark and contact area.
Ordinary support installation and alignment [23] Ordinary joints, connections and alignment checks.	200 average	Colour rendering index $R_a \geq$80; minimum/average uniformity $\geq$0.60. Light joints and alignment targets.
Charging identification and ordinary connections [23] Identification labels and ordinary connection details.	300 average	Colour rendering index $R_a \geq$80; minimum/average uniformity $\geq$0.60. Light identification and connection details.
Visible rock-feature examination and scaling [11] Systematic examination of visible rock, roof and face features.	500 average	Colour rendering index $R_a \geq$80. Use directional or local lighting to reveal visible features and control reflections.
Difficult fine inspection in mining tasks [11] Small, low-contrast or distant critical indications.	750 average	Minimise glare and reflections for sustained fine inspection; use local lighting where required.
Continuous-miner drum/coal interface [8]	20 minimum	Keep light on the working interface throughout cutter movement; control glare and shadows.
W4 – Material handling and processing		
Preparation-plant general work areas [11]	200 average	Ensure safety colours remain recognisable.
Indoor crushers, screens and transfer areas [11]	100 average	Ensure safety colours remain recognisable.
Overland conveyor houses and walkways [11]	100 average	
Picking belts [11]	300 average	Provide IP/flammable protection appropriate to the environment.
Outdoor continuous bulk handling [12]	50 average	Minimum/average uniformity $\geq$0.40; minimum/maximum $\geq$0.20.
Underground conveyor drives, tail ends, transfers and crossings [10]	50 minimum	
Underground ore-loading boxes, bins, flasks, tips and grizzlies [10]	160 minimum	

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Workplace or application	Reference (lx)	Note
Underground crushing and milling stations [10]	160 minimum	
Underground scraper-winch cubbies [10]	100 minimum	
Underground cement and backfill batching plants [10]	100 minimum	
Fixed equipment - potential interaction points [9] One horizontal and four vertical readings at 1 m above floor.	50 equipment test	At each interaction point, at least three of five horizontal/vertical readings must reach 50 lx. Control glare and obstructed views.
W5 – Maintenance, fabrication and inspection		
Rough and average machining [11] Machining tolerances greater than 0.1 mm.	300 average	Use local lighting where obstructions or demanding detail require it.
Precision machining and grinding [11] Machining tolerances less than 0.1 mm.	500 average	Minimise glare and reflections to support comfortable, sustained precision work. Use local lighting where required.
Metalworking scribing and inspection [11]	750 average	Minimise glare and reflections to support comfortable, sustained inspection work. Use local lighting where required.
Rough bench and machine work [11]	200 average	Provide IP protection appropriate to the environment; use local lighting where required.
Medium bench and machine work [11]	400 average	Provide IP protection appropriate to the environment; use local lighting where required.
Outdoor demanding installation and inspection [12]	200 average	Minimum/average uniformity $\geq$0.50; minimum/maximum $\geq$0.33.
Underground workshops - major maintenance [10]	400 minimum	
Underground workshops - service only [10]	200 minimum	
W6 – Utilities, storage and servicing		
Interior plant and switchgear rooms [11]	200 average	
Interior stores and stockrooms [11] Not continuously occupied.	100 average	Use local lighting where racks or obstructions prevent general light reaching the task.
Continuously occupied interior stores [11]	200 average	
Lamp rooms and fan houses [11]	200 average	

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Workplace or application	Reference (lx)	Note
Underground substations and switchgear rooms [10]	100 minimum	
Underground permanent fan chambers above 50 kW [10]	100 minimum	
Underground refrigeration plantrooms [10]	100 minimum	
Underground pump chambers [10]	100 minimum	
Underground battery-charging bays [10]	100 minimum	
W7 – Control, laboratory and administrative work		
Office writing, reading and data processing [11]	500 average	Colour rendering index $R_a \geq$80. Control direct glare and screen reflections to support comfortable prolonged work.
Interior control stations [11] Not continuously occupied.	150 average	
Continuously occupied control stations [11]	200 average	
Winding houses [11]	200 average	
Underground winder and hoist rooms - general provision [10]	20 minimum	
Stationary local cab tasks and non-self-lit controls [42]	50 H minimum	Use controllable local lighting when stationary. During travel keep instruments readable without a caplamp and avoid reflections or brightness that impair the outside view.
W8 – Welfare, medical and emergency facilities		
Change rooms and washrooms [11]	200 average	Colour rendering index $R_a \geq$80.
Rest rooms [11]	100 average	Colour rendering index $R_a \geq$80.
Sick bays [11]	500 average	Colour rendering index $R_a \geq$80. Pay particular attention to glare control and visual comfort.
Underground waiting places and refuge bays [10]	20 minimum	For an occupied refuge, maintain 20 lx under emergency supply throughout the designed occupied emergency period.

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Workplace or application	Reference (lx)	Note
Emergency escape-route lighting [43] Floor centreline of routes up to 2 m wide.	1 emergency minimum	Maintain at least 1 lx on the route centreline. Avoid glare and deep dark patches; maximum/minimum ratio $\leq$40:1. Provide the required duration.
Emergency open-area and anti-panic lighting [43] Empty floor area and its perimeter under the source method.	1 emergency minimum	Maintain at least 1 lx on the empty open-area floor and assess its perimeter as specified. Avoid glare and deep dark patches; maximum/minimum ratio $\leq$40:1.
Emergency exits and access to fire, first-aid and call-point equipment [43] Floor-level provision at equipment and exit locations.	5 emergency minimum	Provide at least 5 lx at floor level at the equipment location and at exits; keep equipment and approaches visible without glare.
Emergency lighting for high-risk task shutdown or continuation [43] Horizontal task average after failure of normal lighting.	20 or 10% of normal task illuminance, whichever is greater emergency average	Provide the greater of 20 lx or 10% of normal task illuminance, continuously or within 0.5 s. Task-to-point illuminance ratio at 5 m $\leq$10:1; limit glare and harmful stroboscopic effects.

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8.2 Emergency operation and equipment checks

Emergency lighting operates after normal-light failure. For escape routes and open areas, provide the required illuminance within 60 s and activate the system no later than 30 s. Maintain minimum-to-maximum uniformity of at least 0.025 (maximum-to-minimum no more than 40:1). Surface escape and open-area provision lasts at least 60 min; underground emergency provision lasts at least 3 h. Hazardous-task lighting reaches its required provision continuously or within 0.5 s and lasts for the period of risk, with a minimum of 30 min on surface or 3 h underground. Occupied refuge lighting retains 20 lx throughout the designed occupied emergency period, which can exceed the escape-lighting duration [43, 10].

For the mobile travel-light test, use equipment lights alone: all three vertical readings at the adopted left, centre and right positions 20 m ahead must be more than 10 lx. The project adopts the stricter wording in the source's summary table. The fixed-equipment test uses one upward horizontal and four vertical readings at 1 m above the floor: at least three of the five must reach 50 lx at every interaction point. The separately adopted 50 lx mobile-interaction criterion applies to the actual interaction surface, rather than transferring that five-direction acceptance rule. Higher task-specific references still apply where relevant [9].

During travel, cab displays must be self-lit and readable without a caplamp. Adjust their brightness and shield local lights to preserve the exterior view and prevent masking windscreen reflections [9].

9 ASSESSING LIGHTING AND CHECKING IMPROVEMENTS

An assessment should answer a stated question. Finding a damaged lamp, checking a selected illuminance reference and investigating whether a worker can see a particular target require different observations. Begin with the lighting application and the purpose of the check, identify the applicable reference, then choose the measurement strategy. Appendix C supplies detailed methods, calculations and a reusable record.

9.1 Choose a proportionate assessment

Table 12: Assessment choices and what their results establish.

Purpose	Useful method	Limit of the conclusion
Routine condition check	Inspect operation, cleanliness, damage, alignment and reported visibility difficulties	Identifies defects; does not verify an area average or validate a lux target.
Screen a known problem	Targeted readings and observations at a task, route feature or suspected dark point	Describes those locations and conditions; does not represent an entire area without a sampling basis.
Verify a selected specification	Measurements using that specification's surface, lighting state, sampling and calculations	Checks that specification under the survey conditions; does not prove sufficient visual performance.
Examine task visibility	Observe the relevant information from representative viewpoints and collect worker feedback	Identifies practical difficulties; a demonstration is not population-wide validation.

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9.2 Select the strategy for the lighting application

First establish whether the reference concerns general lighting of a room or defined area, illumination of a specific visual task, or a route or equipment function. Then read its measurement provisions together with the lux value: the assessed surface, lighting state, required statistic and acceptance method determine where and how to measure. General, localised and task luminaires describe how light is provided; the quantity and surface specified by the reference determine the measurement [26, 3].

For this guide, extensive tunnels and numerous work sites are organised into defined assessment applications rather than treated as one area to be covered by a measurement grid:

- **Room or general-area lighting.** Define the room or bounded zone and apply the matching standard's method for its average, minimum or distribution requirement. Use a grid only where that selected method calls for one, within the area to which the criterion applies.
- **Specific task lighting.** Identify the actual surface and critical detail, such as a bench component, an inclined drawing, a vertical gauge or a rock mark. Measure at the locations and working positions required by the task criterion, with the relevant general and local lighting operating. A room-level reading does not establish the illuminance on every task surface.

- **Routes and equipment functions.** Define the relevant route sections, access features, intersections, changes in lighting and work positions. Use the applicable reference to determine the locations, extent and repetition of measurements. Retain any prescribed equipment-test distance, direction and lighting state separately from ambient workplace measurements.

Document why the chosen locations answer the stated question. Targeted readings can investigate a dark point or guide a correction; they cannot be described as verification of an entire tunnel network or an area average without the sampling basis required for that conclusion. Where the reference's application or measurement method is unclear, resolve that interpretation before declaring compliance.

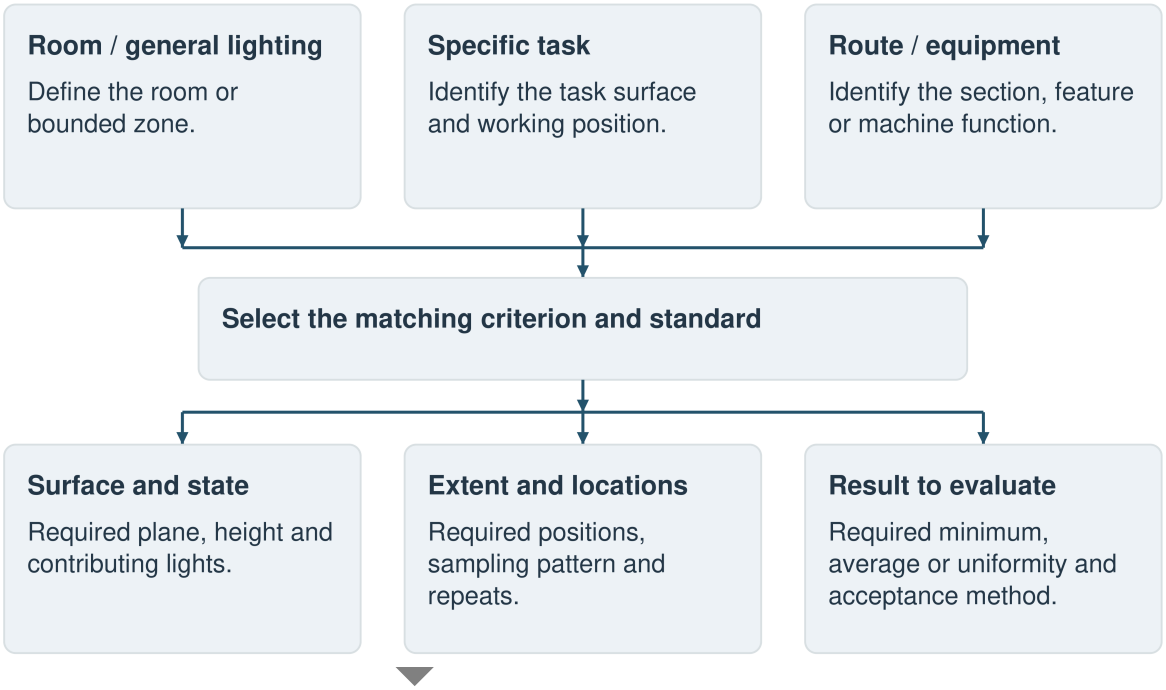


Figure 28: Selecting a lux-measurement strategy from the lighting application and matching reference. This is the project's practical organisation of the assessment, based on the distinction between assessment surfaces, operating conditions and required results [26, 3].

9.3 Prepare the instrument and measure

Use a suitable calibrated illuminance meter reading lux. Check its identity, calibration information, detector condition, battery and range, following the instrument's instructions. The light-sensitive receiving face is the measurement surface; the orientation of a separate display does not define the measured plane [44, 3].

Record whether the assessment includes daylight, caplamps, machine lights and supplementary task lights. For an actual-task assessment, reproduce the contributing lights and operating arrangement being assessed. For an individual system or installation check, control the other contributions as required by the selected method and where safe. Allow the lighting and instrument reading to stabilise; retain relevant operating and maintenance conditions [26, 3].



Figure 29: Remote-detector lux meter at South Deep: detector and display (left), and vertical rock-surface placement (right).

Position the detector. Position the receiving face at the location, height and orientation specified for the assessed surface. Keep it parallel to that surface: upwards for horizontal illuminance, aligned with a vertical or inclined task, and downwards for an overhead underside. Hold this alignment while the reading settles; pointing towards the brightest lamp measures a different plane [26, 3].

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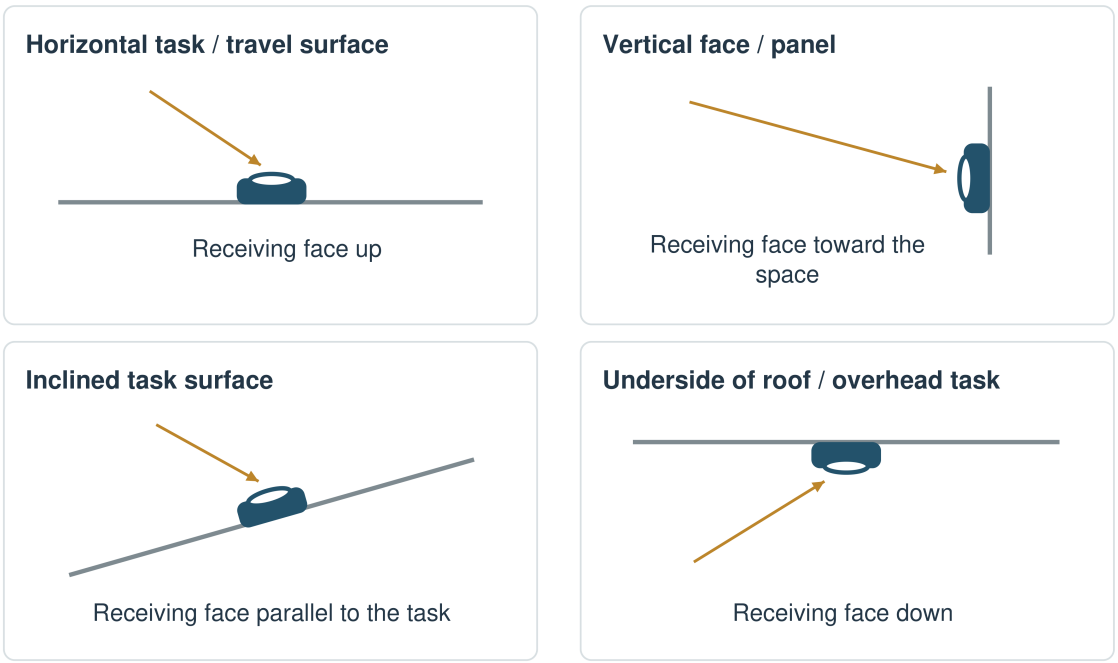
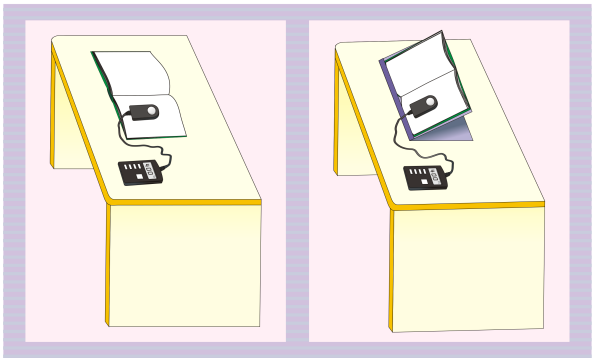


Figure 30: Detector alignment with the assessed surface. White areas show the receiving face; arrows indicate incident light. Use the actual height, positions and lighting state required by the selected criterion [26, 3].

Take and record the required readings. At each required location, place the detector first, stand clear of the relevant light paths and read or log the stable value without changing its position. Avoid adding an accidental shadow or reflection from the assessor, clothing or recording equipment. If the purpose is actual-task assessment, retain the normal shadows

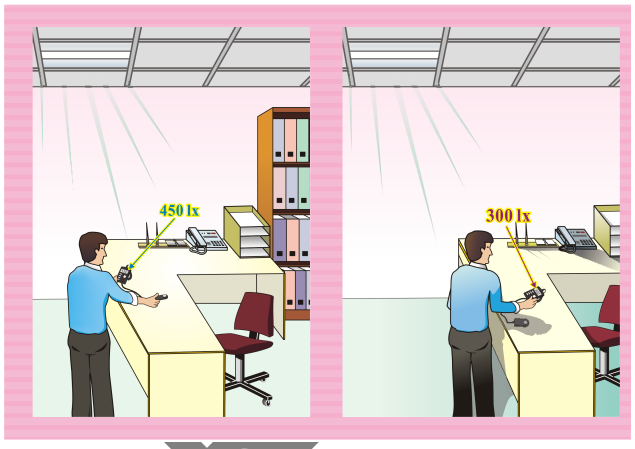
and obstructions associated with the worker and equipment, and identify that operating condition [3, 45].



(a) Place the detector on the work plane.



(b) Hold it vertically for a vertical task.



(c) Shadowing changes the reading.

Figure 31: Match the receiving face to the work plane: (a) a horizontal or inclined reading surface; (b) vertical book spines. (c) Blocking the light path reduces the reading. Avoid an extra shadow from the assessor; retain normal worker shadows when assessing the occupied task. Reproduced from *Lighting Assessment in the Workplace*, Labour Department, Hong Kong [45].

Keep readings linked to identifiable locations or task positions, the measurement plane and the lighting state. Record invalid, unstable or out-of-range readings and investigate their cause. Keep supplementary problem-investigation points identifiable, and repeat the required checks after correction under comparable conditions.

Interpret the results according to the selected reference. Compare an average with an average criterion and a point minimum with the appropriate minimum criterion; evaluate distribution where required. Record a result near a boundary with the instrument and sampling limitations rather than claiming greater precision than the method supports. Detailed calculations and an illustrative example are in Appendix C.

9.4 Check the visual result and respond

Pair the task measurement with the view from the working position. For a roof mark, measure on the relevant roof plane, then observe the mark with the operator, drill and canopy in their representative positions. For a walking zone, measure the floor and inspect the next foothold

on approach. Include the assistant's view and the ordinary caplamp and machine-light contributions. The useful result is recognisable task information without a masking source, reflection or shadow; a reading at an unoccupied, unobstructed point cannot describe every working view [14].

Use the finding to choose the response:

- **Below the applicable illuminance criterion:** restore dirty or defective equipment, correct aim or obstruction, or improve the distribution and task lighting. Repeat the required measurements after the change.
- **The criterion is met but the target remains difficult to see:** identify the masking reflection, exposed source, shadow or blocked sightline. Move, aim, shield or supplement the light as appropriate; use a separate visibility or operating response for structural obstruction. Recheck the target and the affected lighting criteria.
- **One point is satisfactory but another critical position is dark:** extend the assessment to that position and provide useful coverage there. Do not use the first reading or an adequate average to dismiss the dark location.
- **No applicable numerical criterion has been established:** record the readings, task, difficulty and unresolved criterion. Correct identifiable defects and refer the criterion for technical appraisal; do not declare numerical compliance from an unrelated published value.

After adjustment, repeat the affected check in comparable conditions and from the other relevant worker positions. Confirm that reducing glare has retained task, floor and surrounding coverage. A problem that persists across operating positions or cannot be resolved by ordinary optical and maintenance measures warrants specialist lighting assessment.

A satisfactory numerical result establishes conformity with the selected numerical component under the assessed conditions. It does not independently validate the reference value. Record worker observations with their task and conditions. The roof-bolter study's eye-position measurements and glare calculations explain its experimental comparison; they do not supply a general eye-level lux limit or an allowable eye-to-task lux ratio for routine surveys [30]. Choose any specialist glare method for the actual question and geometry rather than importing a research measurement without an interpretation and response.

Keep a usable record. The record should allow another practitioner to understand what was assessed: workplace and activity; reference and source; task surface and points; instrument; lighting and operating state; readings and calculations; observed difficulties; corrective work; and recheck. Use the blank record in Appendix C. Keep the record when the arrangement changes so later assessments can distinguish a genuine change from a different measurement question.

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10 MAINTAINING LIGHTING PERFORMANCE

A lighting-maintenance programme should sustain the visual conditions required for the task throughout operation. It should cover fixed, mobile, temporary, personal and emergency lighting, together with the viewing surfaces and aids that affect visibility. The following recommendations combine the reviewed evidence with practical engineering controls; the supporting project review retains the detailed appraisal and operating examples.

10.1 Evidence and practical implications

The strongest agreement concerns planned maintenance tied to the installed equipment, environment and required lighting performance. ISO/CIE TS 22012 connects maintenance-factor assumptions to cleaning, replacement and surface-refurbishment intervals; ISO/CIE 8995-1 requires those assumptions and the maintenance plan to be documented [46] [23]. These frameworks support planning, but do not establish a single optimum schedule for mines. CIE 97 recognises conditions dirtier than its general industrial classification, so its illustrative intervals cannot be transferred indiscriminately to severe mine contamination [47].

Cleaning can affect the direction of useful light as well as its total output. Davis and colleagues tested seven exterior luminaires from three sites in dirty and cleaned conditions and found changes in luminous-intensity distribution [48]. This supports checking coverage and dark points after service. The small, non-mine sample does not supply a mine cleaning interval or a universal recovery allowance.

Reported mine practice. Project interviews described planned inspections and cleaning alongside reactive replacement and fault reporting. The accounts identified contamination, difficult access, spares availability and repair delays as practical constraints. The recent coal-mine discussion also described scheduled work orders, pre-use checks and action on critical faults between planned visits. These reports show why the programme must connect responsibility, access and restoration; they do not establish industry-wide prevalence, measured retained performance or an optimum interval. The recent notes await participant review, and the accounts were not audited through completed work orders or paired cleaning measurements.

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10.2 Plan the maintenance programme

Assign an accountable programme owner and identify who reports defects, inspects and measures, undertakes competent repairs and authorises return to service. Link each task or zone to its selected lighting criterion, operating mode, exposure and equipment configuration. A consumable fitting can be traced through a stable machine, circuit or zone position; retain individual identity where certification, issue or component history requires it. Work orders should identify the maintaining team and any handover.

Establish a verified clean, correctly aimed baseline for the required task planes and operating states. Record the as-found condition before cleaning so that the service received between interventions remains visible. If the clean installation cannot meet its task criterion, correct the design, obstruction or equipment selection; shorter cleaning intervals alone cannot resolve that deficiency.

Keep design forecasting separate from current-service assessment. A maintenance factor depends on stated equipment, depreciation and maintenance assumptions. Compare

actual as-found performance with the applicable current-service criteria; any separate end-of-cycle projection must retain its own assumptions and calculation basis [46]. In particular, a spot-replacement assumption does not demonstrate adequate lighting while failed fittings await parts: that model assumes immediate replacement by similar equipment [46]. Plan approved spares and safe access to make the intended response achievable.

10.3 Inspect, clean, repair and replace

Diagnose the loss before choosing the intervention. Distinguish removable dirt from scratched or discoloured optics, water ingress, electrical or driver failure, shifted aim and obstruction. Inspect mounts, seals, cables and controls as well as light output. Include windscreens, mirrors, wipers, displays, signs and reflective markings where they contribute to the task [9].

On a machine, follow the light path past the guard, bracket and stored tools to the task. A lamp can be operating while a bent guard or solid mounting rail shades the deck. Restore the specified geometry or obtain an engineered mounting change, then verify the previously dark target. Follow cables through the permitted movement and servicing positions: provide protected movement allowance without snagging loops, and keep covers from pinching the cable. Protect connectors and glands as well as the main run. Where a cable is being used as a handhold, provide the proper access arrangement rather than relying on repeated cable replacement [14].

Plan isolation, access equipment and work-area protection before servicing. Use the actual product's compatible cleaning method; avoid indiscriminate pressure washing, solvents or abrasive treatment of optics, seals and certified assemblies. Cleaning should restore transmission without introducing damage or deposits. Irreversible clouding, cracking or surface deterioration may require replacement rather than repeated cleaning [47].

Repair or replace when required service or equipment integrity is lost. Package lumen retention, including an L_{70} claim, is not proof of whole-system suitability: drivers, connections, optics and environmental stresses also affect service [49]. Confirm that replacement parts preserve optical performance, electrical compatibility, protection and required approvals. Non-equivalent substitutions or settings need engineering review and verification; a brighter replacement can also change glare and coverage.

Where module exchange is the selected maintenance method, provide accessible approved connections, removable mountings and matching preassembled spares. Identify and tag the failed assembly for competent diagnosis and repair, and replenish the spare stock. Quick-change hardware without compatible spares and a repair route cannot deliver the intended restoration. Keep certified enclosures and protection arrangements intact during exchange [14].

SANS 10114-1 favours group relamping in large installations and relates cleaning to replacement economics [11]. Planned group work can reduce repeated access for comparable equipment, but this does not justify delaying correction of a hazardous failure or replacing every component of a mixed LED fleet together. Compare cleaning, repair and replacement at equivalent useful lighting service, including safe-access costs and downtime. The broader energy and life-cycle considerations are addressed in Section 11.

Table 13 summarises system-specific attention within this programme. It is a project synthesis, rather than a prescribed calendar [9].

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Table 13: Maintenance priorities and reasons to recheck lighting.

System or exposure	Maintenance attention	Recheck trigger
Fixed and high-mast lighting	Optics, aim, mounts, corrosion and safe access.	Storms, impact, re-aiming or persistent dark patches.
Mobile equipment and cabs	Work/head lamps, windows, mirrors, wipers, cab controls and operator/pedestrian views.	Damage, changed fittings, glare complaints or shifted beams.
Advancing underground workplaces	Supply, protection and coverage as faces, machines and services move.	Before using a relocated arrangement; after supply or layout changes.
Processing and temporary tasks	Deposits, ingress, stairs, platforms and shadowed maintenance positions.	Washdown, contamination, outages or temporary-light relocation.
Caplamps and portable lights	Optics, issue identity, charge, connections, required modes and retained duty.	Before issue/use; after faults, impact or charging failure.
Emergency and linked systems	Activation, routes/signs, coverage, duration, recharge and affected shared safety functions.	Faults or changes, and the applicable scheduled tests.

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10.4 Set intervals and respond to defects

Set separate arrangements for pre-use observation, technical inspection, photometric verification and cleaning or replacement. A survey interval is not automatically a cleaning interval. Retain a planned maximum interval for each exposure group, supplemented by condition and event triggers. Applicable adopted requirements and equipment-specific duties remain constraints on the plan; a generic lighting calendar cannot extend them. Interior emergency-lighting duties, for example, retain the scope and servicing provisions of SANS 10114-2 rather than being applied unchanged to every underground escape arrangement [43].

Use contamination, operating duty, vibration, ingress, task consequence, measured deterioration and actual restoration time to set and revise intervals. Bring checks forward after impact, blasting or major dust events, washdown, severe weather, relocation, supply/control changes or complaints. Safe operational checks should identify loss of usable visibility without requiring operators to undertake specialist servicing or unsafe access.

Intervene early enough to complete effective restoration before required service is lost. Where a defect already compromises safe task performance or integrity, control the affected activity immediately and verify any temporary arrangement before relying on it; do not wait for the scheduled visit. Temporary lighting needs an owner, defined coverage and supply, an inspection arrangement and a removal or replacement condition. These are project operating principles, not statutory repair deadlines.

Compare repeat as-found and post-cleaning results under comparable conditions before extending an interval. A single satisfactory clean survey cannot show that performance was retained throughout the preceding cycle. The proposed weekly/monthly pilot calendar

remains in the supporting review; no universal cleaning interval is established here.

10.5 Verify restoration and improve the programme

Close work on verified restoration of the affected service. Check physical integrity and approved configuration, then task lighting and distribution under the required operating conditions. Assess the applicable minimum, average and uniformity separately; an adequate average can conceal an unacceptable dark point. Check glare and visibility from the affected worker or operator positions. Section 9 explains the assessment choices; Appendix C gives the detailed methods. Retain uncertainty and the assessment decision explicitly. A satisfactory specification check does not validate the numerical reference.

After repairs or changes, verify the affected control modes, sensor response, overrides and supply-restoration behaviour against the specification [23]. Where emergency or personal lighting is affected, include the required activation, coverage, endurance, charging and recovery checks. Protect necessary service during duration testing and recharge [43]. A lamp-on indication or automatic self-test establishes only the functions actually tested. If a shared caplamp, battery, housing or interface also supports a required safety function, link the relevant competent test evidence before release.

Retain the defect, equipment/position and configuration, work performed, as-found and post-service results, test conditions, remaining restrictions and authorised release. Use comparable baseline points where valid and extend verification across the affected task area after changes to layout, aim or equipment.

Use recurring faults to improve the installation. Concentrated impact damage at one fitting calls for a better protected position or guard; repeated aim loss calls for a secure mounting. Poor recovery after cleaning calls for examination of optical deterioration or a distribution problem. Failures concentrated at a circuit's remote end warrant supply and voltage-drop investigation; a cluster at one machine position may indicate vibration or heat exposure. These patterns suggest causes to test, rather than prove them. Record machine duty and fitting position so competent personnel can distinguish a product fault from an unsuitable application. The handbook illustrates this use of failure records; its legacy lamp failure mechanisms are not assumed to apply unchanged to LEDs [14].

Review retained task performance, overdue critical defects, restoration time and emergency readiness, rather than only counting working fittings or completed visits. Revise the programme when its maintenance assumptions prove impractical. Reliable records and site evaluation should precede claims of optimum schedules or predictive-maintenance benefits; detailed methods and evidence gaps remain in the supporting review.

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11 MANAGING LIGHTING OPERATION AND ENERGY USE

Lighting controls and efficient equipment can reduce unnecessary power and operating hours. Assess changes against the tasks and conditions the installation is intended to serve. A lower electricity bill is useful only alongside a record of the lighting service retained; this chapter explains how to connect those observations.

11.1 Lighting equipment selection

Assess LED and other suitable luminaires on delivered lighting, reliability, controllability and life-cycle cost for the actual application. A direct lamp-for-lamp replacement is not always appropriate. The new luminaire may have a different beam pattern, glare characteristic, colour quality, or light-output depreciation rate. Selection should therefore be based on the light delivered to the work area over the service interval, not only on catalogue efficacy.

For underground service, the specification should cover the expected temperature range, dust and water ingress, vibration, impact, corrosion, and supply-voltage variation. The required mine approval, explosion-protection classification, or intrinsic-safety certification must also be confirmed. Other practical considerations include driver life, flicker, dimming compatibility, cable and connector arrangements, access for cleaning, and the behaviour of the luminaire after a power or control interruption.

Cap-lamp research illustrates why maintained performance matters. A constant-current LED cap lamp retained about 96% of its initial light output after eight hours in one test. Comparable incandescent units fell to approximately 65–69%, depending on the battery type [50]. Longer lamp life also reduces the number of maintenance interventions. This is relevant because lamp replacement may expose workers to electrical, access, mobile-equipment, or work-at-height hazards [51].

Procurement decisions should be supported by a life-cycle cost comparison. Include design, equipment, installation, testing and commissioning, then electricity, safe access, routine cleaning, replacement parts and labour, production disruption during maintenance, and disposal where relevant. Compare options over the same period and for the same required lighting service. State the electricity-price assumptions and each option's operating hours, maintenance and replacement needs within that period [3, 26]. The El Teniente case study found that the economic outcome varied appreciably between LED products. Luminaire price, electricity price, operating hours, and actual service life were all influential, and not every LED option outperformed the fluorescent reference case [52]. A short site trial is therefore useful before a large order is placed.

11.2 Lighting design and optimisation

The design should follow the work being done. Haul roads, pedestrian routes, fixed workstations, production faces, workshops, machine interiors, loading points, and escape routes do not have the same visual requirements. Identifying these task areas helps direct provision towards the important visual demands and limit unnecessary output elsewhere. Check the resulting conditions before concluding that either aim has been achieved.

Photometric calculations can be used to check luminaire type, spacing, mounting height, aiming, and beam distribution. The model should include major obstructions and realistic surface reflectance. A maintenance factor is also needed to account for dirt and light-output depreciation. Commissioning measurements should then confirm illuminance or luminance

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at representative task positions. The inspection should also look for dark patches, severe shadows, poor uniformity, and direct or reflected glare.

Mine studies show that more light does not automatically produce better visibility. Beam distribution, spectrum, mounting position, and the contrast of the target are also important. Properly designed LED cap lamps and machine lights have improved the detection of floor hazards and peripheral movement in simulated underground conditions [5, 4]. Narrow or poorly aimed beams can create glare and leave adjacent areas in shadow [53].

A study on a walk-through roof bolter provides a useful practical example. An LED area light developed for the machine improved trip-object detection compared with the existing compact fluorescent installation. The improvement remained when the LED was operated below full output [6]. This result supports task-based optical design rather than increasing the average illuminance across the whole space.

11.3 Scheduling, zoning, and dimming

Controls are most effective when they reflect how the mine operates. Basic scheduling can align non-critical lighting with production shifts, planned maintenance, and haulage periods. Identify safety-critical, escape and continuously required lighting and coordinate its supply/control arrangements with the relevant mine design and emergency provisions.

Zoning is normally the next step. Permanently occupied workplaces, intermittently used areas, haul routes, maintenance bays, and inactive workings should not be tied to one control circuit. Separate zones allow output to be reduced where activity is low without affecting work elsewhere.

Dimmable installations can use normal, standby, maintenance, and emergency settings. Standby mode should retain a risk-assessed background level rather than leave the area dark. Detection must also occur early enough for the required lighting level to be established before a person or vehicle enters the controlled section. Sudden changes in brightness should be avoided where they could interfere with visual adaptation.

Automatic controls need a local manual override and a defined fail-safe state. Loss of a sensor, controller, or communication link should return the affected zone to a safe output. It should not switch the lighting off. The settings for minimum output, activation distance, hold time, and fade rate should be recorded during commissioning.

Direct mine evidence for advanced lighting controls remains limited. Studies in underground stations have nevertheless shown that occupancy patterns, luminaire ageing, and cleaning intervals can be used to set practical dimming schedules [54]. Road-tunnel systems have also used approaching vehicles, traffic flow, and speed as control inputs [55]. These methods are relevant to mine haul routes and intermittent work areas, although the control settings cannot simply be transferred. They need to be tested against mine traffic, dust, communications, operating rules, and emergency arrangements.

11.4 Smart and adaptive lighting

A smart lighting system links dimmable luminaires with field sensors, local controllers, energy meters, and the mine's supervisory system. Useful inputs may include vehicle or personnel presence, machine status, shift schedules, available daylight near portals, visibility, luminaire faults, and emergency signals. The controller then selects the output required for the current operating condition.

The SEAM4US project demonstrated this type of integrated monitoring and adaptive control in an operating underground station [56]. Its value for mining lies mainly in the system

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architecture: field measurements inform the control decision, the command is applied locally, and the result is monitored. Mine deployment still requires site-specific validation because the operating risks and equipment approvals differ.

Local control remains important. Critical lighting should continue to operate if the central network is unavailable, and an automatic fallback should restore a safe preset. Fault and override events should be logged so that maintenance personnel can distinguish failed equipment from an intentional control action.

A pilot installation is preferable to a mine-wide first deployment. A suitable trial area could be one haulage section, workshop, or intermittently occupied workplace. The trial should record energy use, conformity with selected lighting criteria, sensor reliability, response time, nuisance switching, equipment faults, and feedback from the people using the area.

11.5 Energy monitoring and performance assessment

Lighting energy should be sub-metered by circuit, zone, or equipment group where this is reasonably practicable. Energy data are more useful when they are stored with operating hours, dimming state, fault alarms, and relevant production information. This makes it possible to separate a genuine efficiency improvement from a reduction caused by fewer shifts or a smaller active area.

Useful indicators include:

- lighting energy per shift or month;
- energy per operating hour for each lighting zone;
- time spent at normal, standby, and emergency output;
- the proportion of test points meeting the specified lighting criteria;
- luminaire failure rate, cleaning interval, and measured light depreciation; and
- energy per unit of production, where production conditions are sufficiently stable.

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Comparisons between mines should be treated with care because geometry, mining method, equipment, production rate, and visual tasks vary widely. Internal benchmarking is usually more useful. Comparable areas can be checked against one another, and each area can be compared with its own pre-upgrade baseline. Changes in operating hours, active area, layout, and production should be documented when savings are calculated.

Energy data alone are not sufficient. Lighting measurements must be repeated after an upgrade and at suitable maintenance intervals. The instrument must be appropriate for the source being measured. In an underground coal-mine study, spectral mismatch contributed to luminance errors of approximately 17–26.5% for some instrument and light-source combinations [57]. Measurement position, orientation, distance, and surface condition should therefore be kept consistent.

Use changes in energy use and worker feedback to direct fault-finding. The following observations suggest possible causes to test, rather than prove a fault:

- **Energy rises under comparable operating conditions.** Check for zones left on, unintended overrides and control faults. Correct the confirmed cause, then verify entry response, occupied work and required background lighting before comparing consumption again.

- **Energy falls while routes or task details become harder to see.** Check for failed fittings or premature dimming and restore the required coverage. Recheck the selected numerical criteria and the affected detail from the usual worker or operator positions before reporting a saving.
- **Lighting activates late, switches repeatedly or needs frequent overrides.** Test detection coverage, activation and hold times, and control compatibility during representative person or vehicle approaches. Correct the settings or repair the equipment, then verify timely lighting on approach, coverage during work and the specified fallback after a control failure.

An energy project can be regarded as successful only when the reduction in electricity use is accompanied by continued compliance with the required illumination and visual-safety performance. Where the applicable mine standard gives no single numerical criterion, acceptance should be tied to the documented task assessment and the approved site lighting specification.

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MILESTONE CONCLUSIONS

The revised Milestone 5 draft brings lighting principles, mining evidence and practical assessment into one practitioner sequence. It explains fundamentals before design controls, demonstrates workplace and mobile-equipment applications, and separates concise source-based reference recommendations from the full published-value comparison.

The study's contribution is a transparent synthesis and a practical route through the available advice. It did not establish the numerical sufficiency or insufficiency of individual published lux values for the mining tasks considered. Source credibility and contextual relevance support the use of a reference, but do not validate its visual outcome. A satisfactory installation measurement likewise checks the selected specification under the measured conditions.

The expanded schedule provides 69 reference criteria and completes selection decisions for the nine previously unresolved application groups. Its decision records make the source choice, measurement meaning and project adaptations inspectable. Area minima, task averages, directional equipment checks and emergency criteria are kept distinct. The original published evidence is preserved independently of those selections; completing a reference decision does not complete field validation of its visual outcome.

Further review should examine whether practitioners understand and can apply the guidance, whether the source transfers are appropriate for the intended applications, and what additional field or experimental evidence is needed. The existence of this revised draft does not establish stakeholder acceptance, delivery of every proposed research activity or a demonstrated reduction in accidents.

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LESSONS AND REMAINING RESEARCH QUESTIONS

The revision identifies four lessons for further development. First, a precise-looking lux number is incomplete unless its task and measurement meaning are known. Second, source credibility, local relevance and repeated publication do not independently establish numerical sufficiency. Third, a lighting arrangement must be considered from the viewpoints of the people using the workplace. Fourth, an understandable assessment needs to state what its observations can and cannot establish.

The next appraisal should evaluate the chosen adaptations and measurement protocols in Appendix B, including underground minima, extraction tasks, cab information, mobile interactions and emergency functions. The nine earlier selection gaps now have reference decisions. Further evaluation should test whether the adopted planes, lighting contributions, operating states and acceptance methods represent the intended tasks, and retain any evidence that supports revising a selection.

Practitioner review should ask readers to explain a fundamental in their own words, interpret a reference entry and apply one worked example. Record the task, difficulty and revision prompted by the feedback. This is usability evidence, not validation of a numerical threshold.

Further field and experimental evaluation should examine the relevant visual outcomes under representative conditions. Any subsequent revision of a value or lighting response should preserve the earlier decision, new evidence, reason for change and remaining uncertainty. No universal adjustment multiplier or optimum maintenance interval has been established by this draft.

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NEXT MILESTONE: STAKEHOLDER REVIEW AND FURTHER EVALUATION

The planned stakeholder workshop provides an opportunity to review the draft with practitioners from underground, surface and processing operations. Workshop completion and participant acceptance are not established by this revision. The discussion should distinguish clarity and practical relevance from evidence validating a numerical target.

Use the following questions to structure feedback:

1. Can readers explain the lighting concepts and find advice relevant to their work?
2. Can they identify where a recommended value applies and what a measurement would establish?
3. Do the workplace and mobile-equipment examples reflect important activities and viewpoints?
4. Which selected applications or project adaptations need additional source, operating or measurement evidence?
5. Which inspection and measurement steps are practicable, and where is a more detailed assessment needed?
6. What evaluation would be needed before claiming that a numerical recommendation supports its intended visual outcome?

Record feedback against the draft version and the relevant section or recommendation. Separate wording improvements, new evidence, proposed changes and unresolved questions. Reconcile the local and shared versions before further distribution, preserving concurrent author work. No workshop date, named reviewer or approval is inferred from the document cover or this revision record.

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A CONSOLIDATED PUBLISHED ILLUMINANCE VALUES

This appendix compares published illuminance values for mining workplaces and related industrial tasks. The selected project references are in Section 8; their selection and application are explained in Appendix B. Table 14 lists the original area headings and named evidence-gap entries by workplace family and setting. Click an area name or its printed page number to open that entry. Three additional source criteria follow the W1–W8 comparisons.

Each source row gives the publication, published task and area, illuminance and connection to the mining application. Direct means the named task matches; Comparable identifies a related task or transfer; Weak indicates limited task or setting fit. Apply each value to its published task and measurement basis: minimum, average, maintained or conditional. H and V identify horizontal and vertical illuminance. Exact source passages and review details are in the supporting registers.

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Area index by workplace family. (continued)

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Area index by workplace family. (continued)

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Area index by workplace family. (continued)

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Washroom mirror positions	139

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A.1 W1 - Access and pedestrian movement

Underground - Dynamic workplaces

Table 15: W1 - Underground - Dynamic workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Longwall travelways, cable troughs and AFC approaches			
COL 451, Volume 1 [8]	Longwall/shortwall travelway, cable trough and AFC	**5**; historical minimum background for peripheral vision	**Direct**
Area: Mono-rope pedestrian routes			
GAP 804 [2]	Along the mono-rope	**5**; minimum; statistic unspecified	**Direct**
Area: Raise-bore access areas			
MT/T 1248:2025 [58]	Dedicated pedestrian and haulage roadways	**10**; table minimum; averaging unspecified	**Comparable** — Coal-mine pedestrian-roadway reference for raise-bore access.
GAP 804 [2]	Designated pedestrian walkways	**5**; minimum background	**Direct** — Underground pedestrian access to the raise-bore site.
Area: Stope access and travelling ways			
GAP 804 [2]	Dedicated stope access routes and travelling ways	**5**; minimum background	**Direct**
MVSSA Data Book [10]	Ladderways in vertical shafts	**20**; minimum; grid/ statistic unspecified	**Comparable** — Vertical-shaft ladder reference for stope-route ladder segments.
MT/T 1248:2025 [58]	Dedicated pedestrian and haulage roadways	**10**; table minimum; averaging unspecified	**Comparable** — Coal-mine pedestrian/haulage roadway reference for stope travel.

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Underground - Static workplaces

Table 16: W1 - Underground - Static workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Access crosscuts and ventilation-door approaches			
MVSSA Data Book [10]	Access crosscuts	**20**; minimum; grid/ statistic unspecified	**Direct**
MVSSA Data Book [10]	Ventilation doors	**50**; minimum; grid/ statistic unspecified	**Direct**

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W1 - Underground - Static workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Chairlift access routes and steps			
COL 451, Volume 1 [8]	Typical walking areas near chairlift access	**5**; historical minimum recommendation	**Direct**
COL 451, Volume 1 [8]	Steps near chairlift access	**10-15**; historical recommendation; above typical walking-area level	**Direct**
MVSSA Data Book [10]	Chair lifts - elsewhere	**20**; minimum; grid/ statistic unspecified	**Direct**
Area: Designated underground pedestrian walkways			
GAP 804 [2]	Designated pedestrian walkways	**5**; minimum background	**Direct**
Area: Inclined-shaft walkways and shaft ladderways			
MVSSA Data Book [10]	Ladderways in vertical shafts	**20**; minimum; grid/ statistic unspecified	**Direct**
MVSSA Data Book [10]	Shaft conveyances for man riding	**20**; minimum; grid/ statistic unspecified	**Direct**
MVSSA Data Book [10]	Inclined shafts or ramps with walkway	**20**; minimum; grid/ statistic unspecified	**Direct**
Area: Underground entrances and adaptation zones			
Illustrative entrance example in GAP 804.			
GAP 804 [2]	Top entrance: adaptation into shaft	**250**; illustrative entrance level, not universal limit	**Direct**
Area: Underground haulages and pedestrian routes			
MT/T is coal-mine guidance; its application to other mines is an analogy.			
MVSSA Data Book [10]	Haulages	**20**; minimum; grid/ statistic unspecified	**Direct**
MT/T 1248:2025 [58]	Dedicated pedestrian and haulage roadways	**10**; table minimum; averaging unspecified	**Direct**

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Surface - Surface workplaces

Table 17: W1 - Surface - Surface workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Bench-access footpaths			
DGMS Circular 03/2017 [42]	Bench-to-bench roads and footpaths	**10 H**; source minimum; H horizontal / V vertical	**Direct**
DGMS Circular 03/2017 [42]	Bench-to-bench roads and footpaths	**10 H**; source minimum; H horizontal / V vertical	**Direct**
Area: Pedestrian crossing approaches			
DGMS Circular 03/2017 [42]	Permanent pedestrian paths	**10 H**; source minimum; H horizontal / V vertical	**Direct**
SANS 10389-1:2003 [12]	Walkways exclusively for pedestrians	**5**; minimum maintained average	**Direct**
EN 12464-2:2024 [59]	Walkways exclusively for pedestrians	**5**; maintained average	**Direct**
Area: Pit-entrance and ramp footpaths			
DGMS Circular 03/2017 [42]	Bench-to-bench roads and footpaths	**10 H**; source minimum; H horizontal / V vertical	**Direct**

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Processing - Plant workplaces

Table 18: W1 - Processing - Plant workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Conveyor walkways and houses			
SANS 10114-1:2020 [11]	Overland conveyor houses and walkways	**100**; maintained average E_m; table minimum required level	**Direct**
AS/NZS 1680.2.4:2017 [60]	Mine/quarry conveyors, gantries and wagon loading/ unloading: movement/ orientation	**40**; maintained average	**Direct**
IS 6665:1972 [61]	Conveyor houses, gantries and junction towers	**70-100**; average (Table 2)	**Comparable** — Power-station conveyor-house and gantry lighting applied to mine conveyors.

Shared and supporting facilities - Common and supporting workplaces

Table 19: W1 - Shared and supporting facilities - Common and supporting workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Conveyor walkways and houses			
SANS 10114-1:2020 [11]	Overland conveyor houses and walkways	**100**; maintained average E_m; table minimum required level	**Direct**
AS/NZS 1680.2.4:2017 [60]	Mine/quarry conveyors, gantries and wagon loading/ unloading: movement/ orientation	**40**; maintained average	**Direct**
IS 6665:1972 [61]	Conveyor houses, gantries and junction towers	**70-100**; average (Table 2)	**Comparable** — Power-station conveyor-house and gantry lighting applied to mine conveyors.
Area: Emergency escape routes			
Emergency lighting state.			
SANS 10114-2:2020 [43]	Emergency escape-route centreline	**1**; emergency floor-level minimum	**Direct**
Area: Indoor pedestrian corridors			
SANS 10114-1:2020 [11]	Circulation areas and corridors	**100**; maintained average	**Direct**
ISO/CIE 8995-1:2025 [23]	Pedestrian corridors and circulation areas	**100**; conditional **150**; maintained average; source context modifiers apply	**Direct**
AS/NZS 1680.2.1:2008 [62]	Corridors, passageways and ramps	**40**; maintained average	**Direct**
AS/NZS 1680.0:2009 [63]	Safe movement throughout an interior space	**20**; minimum throughout the space	**Direct**
Area: Indoor stairs			
SANS 10114-1:2020 [11]	Stairs, escalators and travelators	**150**; maintained average	**Direct**
ISO/CIE 8995-1:2025 [23]	Stairs, escalators and travelators	**100**; conditional **150**; maintained average; source context modifiers apply	**Direct**
AS/NZS 1680.2.1:2008 [62]	Internal stairs	**80**; maintained average	**Direct**
Area: Outdoor pedestrian paths			
SANS 10389-1:2003 [12]	Walkways exclusively for pedestrians	**5**; minimum maintained average	**Direct**

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W1 - Shared and supporting facilities - Common and supporting workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
EN 12464-2:2024 [59]	Walkways exclusively for pedestrians	**5**; maintained average	**Direct**
DGMS Circular 03/2017 [42]	Permanent pedestrian paths	**10 H**; source minimum; H horizontal / V vertical	**Direct**
Area: Outdoor stairs and platforms			
EN 12464-2:2024 [59]	Outdoor stairs and ramps	**20**; conditional **30**; maintained average; source context modifiers apply	**Direct**
SANS 10389-1:2003 [12]	Hazardous industries: high-risk pumps, valves, platforms, regular stairs and conveyor crossings	**50**; maintained horizontal average	**Comparable** — High-risk hazardous-industry stairs/ platforms reference.

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A.2 W2 - Transport and mobile-equipment interaction

Underground - Static workplaces

Table 20: W2 - Underground - Static workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Chairlift boarding and alighting positions			
Separate gold/platinum and coal settings; source backgrounds differ.			
GAP 804 [2]	Chairlift boarding/alighting points	**60-80**; recommended range; statistic not specified	**Direct**
COL 451, Volume 1 [8]	Chairlift boarding and alighting	**20-40**; historical recommendation; where shaft background is approximately 5 lx	**Direct**
MVSSA Data Book [10]	Chair lifts - end points	**50**; minimum; grid/ statistic unspecified	**Direct**
Area: Conveyance attachment positions			
GAP 804 [2]	Conveyance attachment points	**30 minimum; about 60 preferred**; historical recommendation	**Direct**
GAP 804 [2]	Track, winding-rope and roller inspection	**30**; historical minimum recommendation	**Direct**
Area: Locomotive operating corridors			
Directional equipment values at 20 m.			
GAP 804 [2]	Locomotive recognition by pedestrians	**10 at 20 m**; historical recommendation	**Direct**
COL 451, Volume 1 [8]	Mobile machinery forward headlighting	**10 at 20 m**; historical equipment/directional recommendation; not general area lux	**Direct**
Area: Mobile-equipment lighting contexts			
Distance-specific equipment values.			
COL 451, Volume 1 [8]	Mobile machinery forward headlighting	**10 at 20 m**; historical equipment/directional recommendation; not general area lux	**Direct**
GAP 804 [2]	Locomotive recognition by pedestrians	**10 at 20 m**; historical recommendation	**Direct**
Area: Shaft stations and landings			
MVSSA Data Book [10]	Shaft stations and shaft sub-banks	**160**; minimum; grid/ statistic unspecified	**Direct**

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W2 - Underground - Static workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
MT/T 1248:2025 [58]	Shaft-bottom yards and adjacent roadways, intersections and coal-face rail roadways	**15**; table minimum; averaging unspecified	**Direct**
Area: Underground locomotive and auxiliary-vehicle garages			
MT/T 1248:2025 [58]	Locomotive and auxiliary-vehicle garages, tippler chambers and self-dumping mine-car unloading stations	**30**; table minimum; averaging unspecified	**Direct**

Surface - Surface workplaces

Table 21: W2 - Surface - Surface workplaces.

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Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Dumping-equipment operator positions			
DGMS Circular 03/2017 [42]	Workplace of heavy machinery	**15 H; 25 V**; source minimum; H horizontal / V vertical; over operating depth and height	**Direct**
DGMS Circular 03/2017 [42]	Machine operator cabins: operating positions	**50 H**; source minimum; H horizontal / V vertical	**Direct**
Area: Haul roads and in-pit transport routes			
DGMS Circular 03/2017 [42]	Truck/dumper haul roads	**10 H**; source minimum; H horizontal / V vertical	**Direct**
SANS 10389-1:2003 [12]	Traffic areas for slowly moving vehicles, maximum 10 km/h	**10**; minimum maintained average	**Comparable** — Vehicle-route reference at the published speed category.
SANS 10389-1:2003 [12]	Regular vehicle traffic, maximum 40 km/h; priority roads of parking areas	**20**; minimum maintained average	**Comparable** — Vehicle-route reference at the published speed category.
EN 12464-2:2024 [59]	Slow vehicle traffic, at most 10 km/h	**10**; maintained average	**Comparable** — Vehicle-route reference at the published speed category.
EN 12464-2:2024 [59]	Regular vehicle traffic, at most 40 km/h	**20**; maintained average	**Comparable** — Vehicle-route reference at the published speed category.
Area: In-pit rail-transport routes			
DGMS Circular 03/2017 [42]	In-pit rail haulage	**10 H**; source minimum; H horizontal / V vertical	**Direct**

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W2 - Surface - Surface workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Intersections and pedestrian crossings			
EN 12464-2:2024 [59]	Mixed traffic, turning and stationary loading/ unloading	**50**; maintained average	**Direct**
SANS 10389-1:2003 [12]	Building-site pedestrian passages, turning and loading/unloading	**50**; maintained horizontal average	**Comparable** — Construction-site movement and turning applied to mine marshalling/crossings.
Area: Loading-equipment operator positions			
DGMS Circular 03/2017 [42]	Workplace of heavy machinery	**15 H; 25 V**; source minimum; H horizontal / V vertical; over operating depth and height	**Direct**
DGMS Circular 03/2017 [42]	Machine operator cabins: operating positions	**50 H**; source minimum; H horizontal / V vertical	**Direct**
Area: Pit entrances and ramps			
DGMS Circular 03/2017 [42]	Truck/dumper haul roads	**10 H**; source minimum; H horizontal / V vertical	**Direct**
SANS 10389-1:2003 [12]	Traffic areas for slowly moving vehicles, maximum 10 km/h	**10**; minimum maintained average	**Comparable** — Vehicle-route reference at the published speed category.
SANS 10389-1:2003 [12]	Regular vehicle traffic, maximum 40 km/h; priority roads of parking areas	**20**; minimum maintained average	**Comparable** — Vehicle-route reference at the published speed category.
EN 12464-2:2024 [59]	Slow vehicle traffic, at most 10 km/h	**10**; maintained average	**Comparable** — Vehicle-route reference at the published speed category.
EN 12464-2:2024 [59]	Regular vehicle traffic, at most 40 km/h	**20**; maintained average	**Comparable** — Vehicle-route reference at the published speed category.
Area: Reclaim-equipment operator positions			
DGMS Circular 03/2017 [42]	Workplace of heavy machinery	**15 H; 25 V**; source minimum; H horizontal / V vertical; over operating depth and height	**Direct**
DGMS Circular 03/2017 [42]	Machine operator cabins: operating positions	**50 H**; source minimum; H horizontal / V vertical	**Direct**

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Shared and supporting facilities - Common and supporting workplaces

Table 22: W2 - Shared and supporting facilities - Common and supporting workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Gate traffic and approaches			
EN 12464-2:2024 [59]	Slow vehicle traffic, at most 10 km/h	**10**; maintained average	**Direct**
EN 12464-2:2024 [59]	Mixed traffic, turning and stationary loading/ unloading	**50**; maintained average	**Direct**
SANS 10389-1:2003 [12]	Traffic areas for slowly moving vehicles, maximum 10 km/h	**10**; minimum maintained average	**Direct**
Area: Indoor parking facilities			
AS/NZS 1680.2.1:2008 [62]	Indoor normal parking spaces	**40**; maintained average	**Direct**
Area: Mixed pedestrian and vehicle areas			
EN 12464-2:2024 [59]	Mixed traffic, turning and stationary loading/ unloading	**50**; maintained average	**Direct**
SANS 10389-1:2003 [12]	Building-site pedestrian passages, turning and loading/unloading	**50**; maintained horizontal average	**Comparable** — Construction-site movement and turning applied to mine marshalling/crossings.
Area: Parking, marshalling and equipment-access areas			
SANS 10389-1:2003 [12]	Parking lots: light traffic	**5**; maintained horizontal average	**Direct**
SANS 10389-1:2003 [12]	Parking lots: medium traffic, including plants	**10**; maintained horizontal average	**Direct**
SANS 10389-1:2003 [12]	Parking lots: heavy traffic	**20**; maintained horizontal average	**Direct**
EN 12464-2:2024 [59]	Parking: light traffic	**5**; maintained average	**Direct**
EN 12464-2:2024 [59]	Parking: medium traffic	**10**; maintained average	**Direct**
EN 12464-2:2024 [59]	Parking: heavy traffic	**20**; maintained average	**Direct**
DGMS Circular 03/2017 [42]	Parking yard	**50 H**; source minimum; H horizontal / V vertical	**Direct**

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Additional named workplaces: evidence gaps

Table 23: W2 - Named workplaces without a dedicated matched comparison record.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
No dedicated matched record in the maintained comparison. Proposal W2; shunting and coupling	**Rail shunting and coupling interfaces** Shared and supporting facilities	Not located in the current extracted comparison.	**Evidence gap.** Source identification and task matching pending.

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A.3 W3 - Extraction, development and construction

Underground - Dynamic workplaces

Table 24: W3 - Underground - Dynamic workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Longwall and shortwall production faces			
MT/T 1248:2025 [58]	Fully mechanised coal face, mobile substations and explosive-issue rooms	**30**; table minimum; averaging unspecified	**Direct**
Area: Production and development headings			
COL 451, Volume 1 [8]	Continuous-miner drum/ coal interface	**20**; historical minimum at the interface; equipment/ task lighting	**Direct**
MT/T 1248:2025 [58]	Fully mechanised coal face, mobile substations and explosive-issue rooms	**30**; table minimum; averaging unspecified	**Weak** — Fully mechanised coal-face reference.
Area: Raise-bore operating areas			
ISO/CIE 8995-1:2025 [23]	Rough assembly	**200**; conditional **300**; maintained average; source context modifiers apply	**Comparable** — Rough/medium/ simple assembly reference for raise-bore setup.
ISO/CIE 8995-1:2025 [23]	Medium assembly	**300**; conditional **500**; maintained average; source context modifiers apply	**Comparable** — Rough/medium/ simple assembly reference for raise-bore setup.
ANSI/IES RP-7-21+E1 [16]	Simple assembly	**300 H; 300 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Comparable** — Rough/medium/ simple assembly reference for raise-bore setup.
Area: Stope and production faces			
No directly named general hard-rock stope-face lux was extracted in this pass.			
MT/T 1248:2025 [58]	Fully mechanised coal face, mobile substations and explosive-issue rooms	**30**; table minimum; averaging unspecified	**Weak** — Fully mechanised coal-face reference.

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Surface - Surface workplaces

Table 25: W3 - Surface - Surface workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Charging and initiation-preparation areas			
DGMS Circular 03/2017 [42]	Places where manual work is done	**15 H; 25 V**; source minimum; H horizontal / V vertical	**Comparable** — Manual-work reference for the charging-preparation area.
SANS 10389-1:2003 [12]	Accurate work; address reading, covered loading platforms and ordinary tool work	**100**; minimum maintained average	**Weak** — General tool/ address-reading reference.
EN 12464-2:2024 [59]	Address reading, tools and ordinary reinforcement/ casting work	**100**; maintained average	**Weak** — General tool/ address-reading reference.
Area: Dragline and bucket-wheel extraction workplaces			
DGMS Circular 03/2017 [42]	Workplace of heavy machinery	**15 H; 25 V**; source minimum; H horizontal / V vertical; over operating depth and height	**Direct**
DGMS Circular 03/2017 [42]	Machine operator cabins: operating positions	**50 H**; source minimum; H horizontal / V vertical	**Direct**
Area: Drill pads and blast-hole drilling positions			
DGMS Circular 03/2017 [42]	Drilling rig: full height	**25 V**; source minimum; H horizontal / V vertical	**Direct**
DGMS Circular 03/2017 [42]	Drill-hole area	**15 H**; source minimum; H horizontal / V vertical	**Direct**
DGMS Circular 03/2017 [42]	Machine operator cabins: operating positions	**50 H**; source minimum; H horizontal / V vertical	**Direct**
Area: Field sampling and grade-control positions			
AS/NZS 1680.2.4:2017 [60]	Mine/quarry lamp rooms, attended material handling/ sampling/bagging, preparation plants and winding houses	**160**; maintained average	**Comparable** — Indoor sampling/ preparation reference applied to open-pit sampling.
SANS 10114-1:2020 [11]	Preparation plants, work areas	**200**; maintained average E_m; table minimum required level	**Comparable** — Indoor sampling/ preparation reference applied to open-pit sampling.
EN 12464-2:2024 [59]	Address reading, tools and ordinary reinforcement/ casting work	**100**; maintained average	**Weak** — General tool/ address-reading reference.

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W3 - Surface - Surface workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Highwalls, berms and pit-edge examination positions			
SANS 10389-1:2003 [12]	Fine work; demanding electrical, machine and piping installation and inspection	**200**; minimum maintained average	**Weak** — Small electrical, machine and piping inspection reference.
EN 12464-2:2024 [59]	Demanding electrical/ machine/piping installation and inspection	**200**; maintained average	**Weak** — Small electrical, machine and piping inspection reference.
Area: Road-construction and grading work zones			
DGMS Circular 03/2017 [42]	Workplace of heavy machinery	**15 H; 25 V**; source minimum; H horizontal / V vertical; over operating depth and height	**Direct**
SANS 10389-1:2003 [12]	Building-site rough work, transport and auxiliary/ storage tasks	**50**; maintained horizontal average	**Comparable** — Construction/ transport reference for road grading.
EN 12464-2:2024 [59]	Building-site transport, construction areas and drain-pipe mounting	**50**; conditional **75**; maintained average; source context modifiers apply	**Comparable** — Construction/ transport reference for road grading.
Area: Stripping, excavation and rehabilitation areas			
DGMS Circular 03/2017 [42]	Workplace of heavy machinery	**15 H; 25 V**; source minimum; H horizontal / V vertical; over operating depth and height	**Direct**
SANS 10389-1:2003 [12]	Building-site clearance, excavation and loading ground	**20**; maintained horizontal average	**Comparable** — Construction excavation/loading reference for mine earthmoving.
EN 12464-2:2024 [59]	Building-site clearance, excavation and loading	**20**; conditional **30**; maintained average; source context modifiers apply	**Comparable** — Construction excavation/loading reference for mine earthmoving.
Area: Working benches and extraction faces			
DGMS Circular 03/2017 [42]	Workplace of heavy machinery	**15 H; 25 V**; source minimum; H horizontal / V vertical; over operating depth and height	**Direct**
DGMS Circular 03/2017 [42]	Machine operator cabins: operating positions	**50 H**; source minimum; H horizontal / V vertical	**Direct**
DGMS Circular 03/2017 [42]	Places where manual work is done	**15 H; 25 V**; source minimum; H horizontal / V vertical	**Direct**
DGMS Circular 03/2017 [42]	Manager-designated general working areas	**10 H**; source minimum; H horizontal / V vertical	**Direct**

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Shared and supporting facilities - Common and supporting workplaces

Table 26: W3 - Shared and supporting facilities - Common and supporting workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Civil construction workplaces			
EN 12464-2:2024 [59]	Building-site transport, construction areas and drain-pipe mounting	**50**; conditional **75**; maintained average; source context modifiers apply	**Comparable** — Outdoor construction-area reference for mine construction.

Additional named workplaces: evidence gaps

Table 27: W3 - Named workplaces without a dedicated matched comparison record.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
No dedicated matched record in the maintained comparison. Proposal W3; concreting	**Concreting workplaces** Shared and supporting facilities	Not located in the current extracted comparison.	**Evidence gap.** Source identification and task matching pending.
No dedicated matched record in the maintained comparison. Proposal W3; erection and temporary works	**Erection and temporary-works areas** Shared and supporting facilities	Not located in the current extracted comparison.	**Evidence gap.** Source identification and task matching pending.

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A.4 W4 - Material handling and processing

Underground - Dynamic workplaces

Table 28: W4 - Underground - Dynamic workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Gullies, scraping and winch operating positions			
GAP 804 [2]	Scraping/gully work needing peripheral hazard awareness	**20**; historical minimum recommendation	**Direct**
MVSSA Data Book [10]	Scraper winch cubbies	**100**; minimum; grid/ statistic unspecified	**Direct**
SIM 160701: earlier framework summary [9]	Hard-rock winches	**20-27**; historical development-stage summary	**Direct** — Hard-rock winch lighting.
Area: Mono-rope material-attachment positions			
GAP 804 [2]	Point where material is tied to the mono-rope	**50**; minimum; statistic unspecified	**Direct**
SIM 160701: earlier framework summary [9]	Hard-rock mono-ropes	**50**; historical development-stage summary	**Comparable** — Mono-rope lighting reference for the attachment area.

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Underground - Production-section workplaces

Table 29: W4 - Underground - Production-section workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Chain-haulage working areas			
SIM 160701: earlier framework summary [9]	Coal chain haulage	**15 across full heading**; historical development-stage summary	**Direct** — Coal chain haulage across the heading.
Area: Section feeder-breaker installations			
SIM 160701: earlier framework summary [9]	Surface in-pit feeder breaker	**40 H**; historical development-stage summary	**Comparable** — Feeder-breaker lighting transferred from surface to underground equipment.
DGMS Circular 03/2017 [42]	In-pit crusher/feeder breaker	**40 H**; source minimum; H horizontal / V vertical	**Comparable** — Feeder-breaker lighting transferred from surface to underground equipment.

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W4 - Underground - Production-section workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Section tips and unloading places			
MVSSA Data Book [10]	Ore loading stations - boxes, bins, flasks, tips, grizzleys	**160**; minimum; grid/ statistic unspecified	**Direct**
MT/T 1248:2025 [58]	Locomotive and auxiliary-vehicle garages, tippler chambers and self-dumping mine-car unloading stations	**30**; table minimum; averaging unspecified	**Direct**

Underground - Static workplaces

Table 30: W4 - Underground - Static workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Cement and backfill batching plants			
MVSSA Data Book [10]	Cement and backfill batching plants	**100**; minimum; grid/ statistic unspecified	**Direct**
ISO/CIE 8995-1:2025 [23]	Cement/concrete/brick industry: material preparation and kiln/mixer work	**200**; conditional **300**; maintained average; source context modifiers apply	**Comparable** — Cement/concrete preparation and mixer work applied to backfill batching.
Area: Conveyor transfer points, drives, tail ends and crossings			
MVSSA Data Book [10]	Conveyor beltways: drives, tail-ends, transfer points and crossings	**50**; minimum; grid/ statistic unspecified	**Direct**
SIM 160701: earlier framework summary [9]	Surface/underground conveyor transfer points	**40 H**; historical development-stage summary	**Direct** — Conveyor/transfer task in the same setting.
Area: Conveyor-length operating areas			
SIM 160701: earlier framework summary [9]	Along surface/underground conveyor	**20 H**; historical development-stage summary	**Direct** — Conveyor/transfer task in the same setting.
Area: Ore-tipping places			
MVSSA Data Book [10]	Ore loading stations - boxes, bins, flasks, tips, grizzleys	**160**; minimum; grid/ statistic unspecified	**Direct**

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W4 - Underground - Static workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
MT/T 1248:2025 [58]	Locomotive and auxiliary-vehicle garages, tippler chambers and self-dumping mine-car unloading stations	**30**; table minimum; averaging unspecified	**Direct**
GAP 804 [2]	Tip track level	**30**; historical likely minimum recommendation	**Direct**
GAP 804 [2]	Tip controls	**60**; historical likely minimum recommendation	**Direct**
Area: Orepass boxes, loading platforms and lips			
MVSSA Data Book [10]	Ore loading stations - boxes, bins, flasks, tips, grizzleys	**160**; minimum; grid/ statistic unspecified	**Direct**
GAP 804 [2]	Orepass platforms and haulage-level access	**20**; historical minimum recommendation	**Direct**
GAP 804 [2]	Orepass lips: blockage/ water-seepage observation	**about 60**; historical approximate recommendation; not a point minimum	**Direct**
Area: Underground crusher stations			
MVSSA Data Book [10]	Underground crushing and milling stations	**160**; minimum; grid/ statistic unspecified	**Direct**
SANS 10114-1:2020 [11]	Pulverisers, crushers, screens, feeder points, transfer areas	**100**; maintained average E_m; table minimum required level	**Comparable** — Surface-building crushing/feeder reference applied underground.
ANSI/IES RP-7-21+E1 [16]	Coarse raw-material cleaning/cutting/crushing/ sorting/grading	**100 H; 100 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct** — Coarse raw-material crushing underground.

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Surface - Surface workplaces

Table 31: W4 - Surface - Surface workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: In-pit crushers and feeder breakers			
DGMS Circular 03/2017 [42]	In-pit crusher/feeder breaker	**40 H**; source minimum; H horizontal / V vertical	**Direct**
SIM 160701: earlier framework summary [9]	Surface in-pit crusher	**50 H**; historical development-stage summary	**Direct** — Surface in-pit crusher or feeder-breaker lighting.
SIM 160701: earlier framework summary [9]	Surface in-pit feeder breaker	**40 H**; historical development-stage summary	**Direct** — Surface in-pit crusher or feeder-breaker lighting.
DGMS Circular 03/2017 [42]	Mineral/ore plant crushing, screening, segregation and loading/unloading	**40 H**; source minimum; H horizontal / V vertical	**Direct**
DGMS Circular 03/2017 [42]	Mineral/ore plant operating points	**50 H**; source minimum; H horizontal / V vertical	**Direct**
SANS 10114-1:2020 [11]	Pulverisers, crushers, screens, feeder points, transfer areas	**100**; maintained average E_m; table minimum required level	**Comparable** — Indoor crusher/ feeder reference applied to open-pit/mobile equipment.
Area: Reclaim and loader working areas			
DGMS Circular 03/2017 [42]	Loading/unloading/transfer, dumps and ore-stack yards	**15 H; 15 V**; source minimum; H horizontal / V vertical	**Direct**
SANS 10389-1:2003 [12]	Very rough work; short-term handling of large units/raw materials and solid bulk goods	**20**; minimum maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.
SANS 10389-1:2003 [12]	Rough work; continuous handling of large units/raw materials, freight loading/ unloading and open loading platforms	**50**; minimum maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.
EN 12464-2:2024 [59]	Short-term handling/loading of large units and raw materials	**20**; maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.
EN 12464-2:2024 [59]	Continuous handling/ loading of large units and raw materials	**50**; maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.
Area: ROM stockpiles and dumping areas			
DGMS Circular 03/2017 [42]	Loading/unloading/transfer, dumps and ore-stack yards	**15 H; 15 V**; source minimum; H horizontal / V vertical	**Direct**

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W4 - Surface - Surface workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
SANS 10389-1:2003 [12]	Very rough work; short-term handling of large units/raw materials and solid bulk goods	**20**; minimum maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.
SANS 10389-1:2003 [12]	Rough work; continuous handling of large units/raw materials, freight loading/ unloading and open loading platforms	**50**; minimum maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.
EN 12464-2:2024 [59]	Short-term handling/loading of large units and raw materials	**20**; maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.
EN 12464-2:2024 [59]	Continuous handling/ loading of large units and raw materials	**50**; maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.
ANSI/IES RP-7-21+E1 [16]	Active storage yards	**50 H; 15 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**
ANSI/IES RP-7-21+E1 [16]	Inactive storage yards	**10 H; 2 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**
IS 6665:1972 [61]	Coal storage areas	**20**; average (Table 2)	**Comparable** — Coal/steelworks stockyard reference.
IS 6665:1972 [61]	Marshalling and outdoor stockyards	**10-20**; average (Table 2)	**Comparable** — Coal/steelworks stockyard reference.
Area: Shovel-loading and truck-spotting areas			
DGMS Circular 03/2017 [42]	Loading/unloading/transfer, dumps and ore-stack yards	**15 H; 15 V**; source minimum; H horizontal / V vertical	**Direct**
SANS 10389-1:2003 [12]	Very rough work; short-term handling of large units/raw materials and solid bulk goods	**20**; minimum maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.
SANS 10389-1:2003 [12]	Rough work; continuous handling of large units/raw materials, freight loading/ unloading and open loading platforms	**50**; minimum maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.

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W4 - Surface - Surface workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
EN 12464-2:2024 [59]	Short-term handling/loading of large units and raw materials	**20**; maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.
EN 12464-2:2024 [59]	Continuous handling/ loading of large units and raw materials	**50**; maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.
Area: Waste dumps and tipping areas			
DGMS Circular 03/2017 [42]	Loading/unloading/transfer, dumps and ore-stack yards	**15 H; 15 V**; source minimum; H horizontal / V vertical	**Direct**
SANS 10389-1:2003 [12]	Very rough work; short-term handling of large units/raw materials and solid bulk goods	**20**; minimum maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.
SANS 10389-1:2003 [12]	Rough work; continuous handling of large units/raw materials, freight loading/ unloading and open loading platforms	**50**; minimum maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.
EN 12464-2:2024 [59]	Short-term handling/loading of large units and raw materials	**20**; maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.
EN 12464-2:2024 [59]	Continuous handling/ loading of large units and raw materials	**50**; maintained average	**Comparable** — Bulk-handling reference for spotting and dumping.

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Processing - Plant workplaces

Table 32: W4 - Processing - Plant workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Active and inactive stockyards			
ANSI/IES RP-7-21+E1 [16]	Active storage yards	**50 H; 15 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**

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W4 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
ANSI/IES RP-7-21+E1 [16]	Inactive storage yards	**10 H; 2 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**
IS 6665:1972 [61]	Coal storage areas	**20**; average (Table 2)	**Comparable** — Coal/steelworks stockyard reference.
IS 6665:1972 [61]	Marshalling and outdoor stockyards	**10-20**; average (Table 2)	**Comparable** — Coal/steelworks stockyard reference.
Area: Bagging, packaging and palletising areas			
AS/NZS 1680.2.4:2017 [60]	Mine/quarry lamp rooms, attended material handling/ sampling/bagging, preparation plants and winding houses	**160**; maintained average	**Direct**
SANS 10114-1:2020 [11]	Dispatch packing and handling	**300**; maintained average	**Direct**
ISO/CIE 8995-1:2025 [23]	Dispatch packing and handling	**300**; conditional **500**; maintained average; source context modifiers apply	**Direct**
AS/NZS 1680.2.4:2017 [60]	Packing/dispatch/wrapping/ labelling/filling/stamping: small objects	**240**; maintained average	**Direct**
AS/NZS 1680.2.4:2017 [60]	Storage with routine reading; large-object packing/dispatch/wrapping/ labelling	**160**; maintained average	**Direct**
ANSI/IES RP-7-21+E1 [16]	Wrapping, packing and labelling	**300 H; 150 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**
Area: Conveyor transfer points, drives and tail ends			
SANS 10114-1:2020 [11]	Pulverisers, crushers, screens, feeder points, transfer areas	**100**; maintained average E_m; table minimum required level	**Direct**
AS/NZS 1680.2.4:2017 [60]	Mine/quarry material handling: general transfer houses, silos/elevators and tipplers	**80**; maintained average	**Direct**

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W4 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
DGMS Circular 03/2017 [42]	Conveyor transfer and drive/ tail-end areas	**40 H**; source minimum; H horizontal / V vertical	**Direct**
SIM 160701: earlier framework summary [9]	Surface/underground conveyor transfer points	**40 H**; historical development-stage summary	**Direct** — Conveyor/transfer task in the same setting.
Area: Covered reclaim tunnels and storage tanks			
SANS 10114-1:2020 [11]	Tunnel, covered walkways, storage tanks	**50**; maintained average E_m; table minimum required level	**Direct**
Area: Crushing and screening areas			
SANS 10114-1:2020 [11]	Pulverisers, crushers, screens, feeder points, transfer areas	**100**; maintained average E_m; table minimum required level	**Direct**
DGMS Circular 03/2017 [42]	Mineral/ore plant crushing, screening, segregation and loading/unloading	**40 H**; source minimum; H horizontal / V vertical	**Direct**
AS/NZS 1680.2.4:2017 [60]	Mine/quarry lamp rooms, attended material handling/ sampling/bagging, preparation plants and winding houses	**160**; maintained average	**Direct** — General preparation-plant work and attended material handling.
ANSI/IES RP-7-21+E1 [16]	Coarse raw-material cleaning/cutting/crushing/ sorting/grading	**100 H; 100 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct** — Coarse raw-material crushing/sorting.
DGMS Circular 03/2017 [42]	Mineral/ore plant operating points	**50 H**; source minimum; H horizontal / V vertical	**Direct**
SANS 10114-1:2020 [11]	Preparation plants, work areas	**200**; maintained average E_m; table minimum required level	**Direct** — General indoor preparation-plant work.
AS/NZS 1680.2.4:2017 [60]	Mine/quarry lamp rooms, attended material handling/ sampling/bagging, preparation plants and winding houses	**160**; maintained average	**Direct** — General indoor preparation-plant work.
IS 6665:1972 [61]	Coal preparation plant: working areas	**150**; average (Table 2)	**Direct** — General indoor preparation-plant work.
IS 6665:1972 [61]	Coal preparation plant: other areas	**100**; average (Table 2)	**Direct**
DGMS Circular 03/2017 [42]	Other mineral/ore plant areas	**20 H**; source minimum; H horizontal / V vertical	**Direct**

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W4 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Drying, kiln and thermal-treatment areas			
ISO/CIE 8995-1:2025 [23]	Cement/concrete/brick industry: drying	**50**; maintained average	**Comparable** — Cement/concrete/brick drying and kiln work applied to mineral processing.
ISO/CIE 8995-1:2025 [23]	Cement/concrete/brick industry: material preparation and kiln/mixer work	**200**; conditional **300**; maintained average; source context modifiers apply	**Comparable** — Cement/concrete/brick drying and kiln work applied to mineral processing.
IS 6665:1972 [61]	Chemical works: furnaces, boiling tanks, driers, crystallisers, filtration, extractors and electrolytic cells	**150**; average (Table 2)	**Comparable** — Chemical-works filtration/drying applied to mineral processing.
Area: Flotation process areas			
ISO/CIE 8995-1:2025 [23]	Chemical processing: remote-controlled installations	**50**; maintained average	**Comparable** — Chemical-process reference by attendance and visual-task class.
ISO/CIE 8995-1:2025 [23]	Chemical processing: limited manual intervention	**150**; conditional **200**; maintained average; source context modifiers apply	**Comparable** — Chemical-process reference by attendance and visual-task class.
ISO/CIE 8995-1:2025 [23]	Chemical processing: constantly manned workstations	**300**; conditional **500**; maintained average; source context modifiers apply	**Comparable** — Chemical-process reference by attendance and visual-task class.
AS/NZS 1680.2.4:2017 [60]	Petroleum/chemical process plant: remote control or occasional manual intervention	**80**; maintained average	**Comparable** — Chemical-process reference by attendance and visual-task class.
AS/NZS 1680.2.4:2017 [60]	Petroleum/chemical pump/compressor houses and permanently occupied process workstations	**160**; maintained average	**Comparable** — Chemical-process reference by attendance and visual-task class.
SANS 10389-1:2003 [12]	Hazardous industries: manual valves, starting/stopping motors, service tools	**20**; maintained horizontal average	**Direct** — Outdoor chemical/hazardous-process task at the published risk category.
SANS 10389-1:2003 [12]	Hazardous industries: risk-free loading and leakage/piping inspection	**50**; maintained horizontal average	**Direct** — Outdoor chemical/hazardous-process task at the published risk category.
SANS 10389-1:2003 [12]	Hazardous industries: dangerous-substance transfer, pump packing, servicing and instruments	**100**; maintained horizontal average	**Direct** — Outdoor chemical/hazardous-process task at the published risk category.
EN 12464-2:2024 [59]	Chemical industries: service tools, manual valves and motor start/stop	**20**; conditional **30**; maintained average; source context modifiers apply	**Direct** — Outdoor chemical/hazardous-process task at the published risk category.

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W4 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
EN 12464-2:2024 [59]	Chemical industries: risk-free loading and leakage/piping inspection	**50**; conditional **75**; maintained average; source context modifiers apply	**Direct** — Outdoor chemical/ hazardous-process task at the published risk category.
EN 12464-2:2024 [59]	Chemical industries: dangerous-substance transfer, pump packing, service and instruments	**100**; conditional **150**; maintained average; source context modifiers apply	**Direct** — Outdoor chemical/ hazardous-process task at the published risk category.
IS 6665:1972 [61]	Chemical works: furnaces, boiling tanks, driers, crystallisers, filtration, extractors and electrolytic cells	**150**; average (Table 2)	**Comparable** — Chemical unit-operation reference for mineral processing.
IS 6665:1972 [61]	Chemical works: controls, gauges and valves	**100**; average (Table 2)	**Direct** — Chemical-process controls, gauges and valves.
Area: Gravity and dense-medium separation areas			
SANS 10114-1:2020 [11]	Preparation plants, work areas	**200**; maintained average E_m; table minimum required level	**Direct** — General preparation-process operations.
AS/NZS 1680.2.4:2017 [60]	Mine/quarry lamp rooms, attended material handling/ sampling/bagging, preparation plants and winding houses	**160**; maintained average	**Direct** — General preparation-process operations.
DGMS Circular 03/2017 [42]	Mineral/ore plant operating points	**50 H**; source minimum; H horizontal / V vertical	**Direct** — General preparation-process operations.
IS 6665:1972 [61]	Coal preparation plant: working areas	**150**; average (Table 2)	**Direct** — General preparation-process operations.
Area: Leaching, adsorption and recovery areas			
ISO/CIE 8995-1:2025 [23]	Chemical processing: remote-controlled installations	**50**; maintained average	**Comparable** — Chemical-process reference by attendance and visual-task class.
ISO/CIE 8995-1:2025 [23]	Chemical processing: limited manual intervention	**150**; conditional **200**; maintained average; source context modifiers apply	**Comparable** — Chemical-process reference by attendance and visual-task class.
ISO/CIE 8995-1:2025 [23]	Chemical processing: constantly manned workstations	**300**; conditional **500**; maintained average; source context modifiers apply	**Comparable** — Chemical-process reference by attendance and visual-task class.
AS/NZS 1680.2.4:2017 [60]	Petroleum/chemical process plant: remote control or occasional manual intervention	**80**; maintained average	**Comparable** — Chemical-process reference by attendance and visual-task class.

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W4 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
AS/NZS 1680.2.4:2017 [60]	Petroleum/chemical pump/ compressor houses and permanently occupied process workstations	**160**; maintained average	**Comparable** — Chemical-process reference by attendance and visual-task class.
SANS 10389-1:2003 [12]	Hazardous industries: manual valves, starting/ stopping motors, service tools	**20**; maintained horizontal average	**Direct** — Outdoor chemical/ hazardous-process task at the published risk category.
SANS 10389-1:2003 [12]	Hazardous industries: risk-free loading and leakage/piping inspection	**50**; maintained horizontal average	**Direct** — Outdoor chemical/ hazardous-process task at the published risk category.
SANS 10389-1:2003 [12]	Hazardous industries: dangerous-substance transfer, pump packing, servicing and instruments	**100**; maintained horizontal average	**Direct** — Outdoor chemical/ hazardous-process task at the published risk category.
EN 12464-2:2024 [59]	Chemical industries: service tools, manual valves and motor start/stop	**20**; conditional **30**; maintained average; source context modifiers apply	**Direct** — Outdoor chemical/ hazardous-process task at the published risk category.
EN 12464-2:2024 [59]	Chemical industries: risk-free loading and leakage/piping inspection	**50**; conditional **75**; maintained average; source context modifiers apply	**Direct** — Outdoor chemical/ hazardous-process task at the published risk category.
EN 12464-2:2024 [59]	Chemical industries: dangerous-substance transfer, pump packing, service and instruments	**100**; conditional **150**; maintained average; source context modifiers apply	**Direct** — Outdoor chemical/ hazardous-process task at the published risk category.
IS 6665:1972 [61]	Chemical works: furnaces, boiling tanks, driers, crystallisers, filtration, extractors and electrolytic cells	**150**; average (Table 2)	**Comparable** — Chemical unit-operation reference for mineral processing.
IS 6665:1972 [61]	Chemical works: controls, gauges and valves	**100**; average (Table 2)	**Direct** — Chemical-process controls, gauges and valves.
Area: Magnetic, electrostatic and sensor-separation areas			
SANS 10114-1:2020 [11]	Preparation plants, work areas	**200**; maintained average E_m; table minimum required level	**Direct** — General preparation-process operations.
AS/NZS 1680.2.4:2017 [60]	Mine/quarry lamp rooms, attended material handling/ sampling/bagging, preparation plants and winding houses	**160**; maintained average	**Direct** — General preparation-process operations.
DGMS Circular 03/2017 [42]	Mineral/ore plant operating points	**50 H**; source minimum; H horizontal / V vertical	**Direct** — General preparation-process operations.
IS 6665:1972 [61]	Coal preparation plant: working areas	**150**; average (Table 2)	**Direct** — General preparation-process operations.

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W4 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
SANS 10389-1:2003 [12]	Fine work; demanding electrical, machine and piping installation and inspection	**200**; minimum maintained average	**Weak** — Demanding industrial installation/inspection reference.
EN 12464-2:2024 [59]	Demanding electrical/ machine/piping installation and inspection	**200**; maintained average	**Weak** — Demanding industrial installation/inspection reference.
Area: Manual picking belts			
SANS/AS concern indoor preparation plants; DGMS minimum concerns opencast metalliferous hand picking.			
SANS 10114-1:2020 [11]	Picking belts	**300**; maintained average E_m; table minimum required level	**Direct**
AS/NZS 1680.2.4:2017 [60]	Mine/quarry preparation plants: picking belts	**400**; maintained average	**Direct**
DGMS Circular 03/2017 [42]	Hand-picking points	**50 H**; source minimum; H horizontal / V vertical	**Direct**
IS 6665:1972 [61]	Picking belts	**300**; average (Table 2)	**Direct**
Area: Milling, grinding and classification areas			
SANS 10114-1:2020 [11]	Preparation plants, work areas	**200**; maintained average E_m; table minimum required level	**Direct** — General preparation-process operations.
AS/NZS 1680.2.4:2017 [60]	Mine/quarry lamp rooms, attended material handling/ sampling/bagging, preparation plants and winding houses	**160**; maintained average	**Direct** — General preparation-process operations.
DGMS Circular 03/2017 [42]	Mineral/ore plant operating points	**50 H**; source minimum; H horizontal / V vertical	**Direct** — General preparation-process operations.
IS 6665:1972 [61]	Coal preparation plant: working areas	**150**; average (Table 2)	**Direct** — General preparation-process operations.
ANSI/IES RP-7-21+E1 [16]	Coarse raw-material cleaning/cutting/crushing/ sorting/grading	**100 H; 100 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Comparable** — Raw-material processing reference by visual-detail class.
ANSI/IES RP-7-21+E1 [16]	Medium raw-material processing	**300 H; 300 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Comparable** — Raw-material processing reference by visual-detail class.

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W4 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
ANSI/IES RP-7-21+E1 [16]	Fine raw-material processing	**500 H; 500 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Comparable** — Raw-material processing reference by visual-detail class.
Area: Opencast conveyor routes			
DGMS Circular 03/2017 [42]	Along conveyors	**20 H**; source minimum; H horizontal / V vertical	**Direct**
SIM 160701: earlier framework summary [9]	Along surface/underground conveyor	**20 H**; historical development-stage summary	**Direct** — Conveyor/transfer task in the same setting.
Area: Ore-receiving and tipping areas			
AS/NZS 1680.2.4:2017 [60]	Mine/quarry material handling: general transfer houses, silos/elevators and tipplers	**80**; maintained average	**Direct**
DGMS Circular 03/2017 [42]	Mineral/ore plant crushing, screening, segregation and loading/unloading	**40 H**; source minimum; H horizontal / V vertical	**Direct**
SANS 10114-1:2020 [11]	Pulverisers, crushers, screens, feeder points, transfer areas	**100**; maintained average E_m; table minimum required level	**Direct** — Ore receiving/tipping at a feeder or transfer area.
SANS 10389-1:2003 [12]	Very rough work; short-term handling of large units/raw materials and solid bulk goods	**20**; minimum maintained average	**Direct**
SANS 10389-1:2003 [12]	Rough work; continuous handling of large units/raw materials, freight loading/ unloading and open loading platforms	**50**; minimum maintained average	**Direct**
EN 12464-2:2024 [59]	Short-term handling/loading of large units and raw materials	**20**; maintained average	**Direct**
EN 12464-2:2024 [59]	Continuous handling/ loading of large units and raw materials	**50**; maintained average	**Direct**
DGMS Circular 03/2017 [42]	Loading/unloading/transfer, dumps and ore-stack yards	**15 H; 15 V**; source minimum; H horizontal / V vertical	**Direct**
IS 6665:1972 [61]	Coal unloading areas	**20**; average (Table 2)	**Comparable** — Power-station coal unloading applied to bulk load-out.

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W4 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Outdoor conveyors			
IS 6665:1972 [61]	Conveyors	**50**; average (Table 2)	**Comparable** — Power-station outdoor conveyor reference applied to mine conveyors.
Area: Outdoor process conveyors and crossings			
SANS hazardous-process task class.			
SANS 10389-1:2003 [12]	Hazardous industries: medium-risk areas, including conveyors	**20**; maintained horizontal average	**Direct**
SANS 10389-1:2003 [12]	Hazardous industries: high-risk pumps, valves, platforms, regular stairs and conveyor crossings	**50**; maintained horizontal average	**Direct**
Area: Product stockpiles and storage buildings			
SANS 10389-1:2003 [12]	Very rough work; short-term handling of large units/raw materials and solid bulk goods	**20**; minimum maintained average	**Direct**
SANS 10389-1:2003 [12]	Rough work; continuous handling of large units/raw materials, freight loading/ unloading and open loading platforms	**50**; minimum maintained average	**Direct**
EN 12464-2:2024 [59]	Short-term handling/loading of large units and raw materials	**20**; maintained average	**Direct**
EN 12464-2:2024 [59]	Continuous handling/ loading of large units and raw materials	**50**; maintained average	**Direct**
DGMS Circular 03/2017 [42]	Loading/unloading/transfer, dumps and ore-stack yards	**15 H; 15 V**; source minimum; H horizontal / V vertical	**Direct**
ANSI/IES RP-7-21+E1 [16]	Active storage yards	**50 H; 15 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**
ANSI/IES RP-7-21+E1 [16]	Inactive storage yards	**10 H; 2 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**

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W4 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
IS 6665:1972 [61]	Coal storage areas	**20**; average (Table 2)	**Comparable** — Coal/steelworks stockyard reference.
IS 6665:1972 [61]	Marshalling and outdoor stockyards	**10-20**; average (Table 2)	**Comparable** — Coal/steelworks stockyard reference.
Area: Reagent preparation and dosing areas			
ISO/CIE 8995-1:2025 [23]	Chemical processing: remote-controlled installations	**50**; maintained average	**Comparable** — Chemical-process reference by attendance and visual-task class.
ISO/CIE 8995-1:2025 [23]	Chemical processing: limited manual intervention	**150**; conditional **200**; maintained average; source context modifiers apply	**Comparable** — Chemical-process reference by attendance and visual-task class.
ISO/CIE 8995-1:2025 [23]	Chemical processing: constantly manned workstations	**300**; conditional **500**; maintained average; source context modifiers apply	**Comparable** — Chemical-process reference by attendance and visual-task class.
AS/NZS 1680.2.4:2017 [60]	Petroleum/chemical process plant: remote control or occasional manual intervention	**80**; maintained average	**Comparable** — Chemical-process reference by attendance and visual-task class.
AS/NZS 1680.2.4:2017 [60]	Petroleum/chemical pump/ compressor houses and permanently occupied process workstations	**160**; maintained average	**Comparable** — Chemical-process reference by attendance and visual-task class.
SANS 10389-1:2003 [12]	Hazardous industries: manual valves, starting/ stopping motors, service tools	**20**; maintained horizontal average	**Direct** — Outdoor chemical/ hazardous-process task at the published risk category.
SANS 10389-1:2003 [12]	Hazardous industries: risk-free loading and leakage/piping inspection	**50**; maintained horizontal average	**Direct** — Outdoor chemical/ hazardous-process task at the published risk category.
SANS 10389-1:2003 [12]	Hazardous industries: dangerous-substance transfer, pump packing, servicing and instruments	**100**; maintained horizontal average	**Direct** — Outdoor chemical/ hazardous-process task at the published risk category.
EN 12464-2:2024 [59]	Chemical industries: service tools, manual valves and motor start/stop	**20**; conditional **30**; maintained average; source context modifiers apply	**Direct** — Outdoor chemical/ hazardous-process task at the published risk category.
EN 12464-2:2024 [59]	Chemical industries: risk-free loading and leakage/piping inspection	**50**; conditional **75**; maintained average; source context modifiers apply	**Direct** — Outdoor chemical/ hazardous-process task at the published risk category.
EN 12464-2:2024 [59]	Chemical industries: dangerous-substance transfer, pump packing, service and instruments	**100**; conditional **150**; maintained average; source context modifiers apply	**Direct** — Outdoor chemical/ hazardous-process task at the published risk category.

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W4 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
IS 6665:1972 [61]	Chemical works: furnaces, boiling tanks, driers, crystallisers, filtration, extractors and electrolytic cells	**150**; average (Table 2)	**Comparable** — Chemical unit-operation reference for mineral processing.
IS 6665:1972 [61]	Chemical works: controls, gauges and valves	**100**; average (Table 2)	**Direct** — Chemical-process controls, gauges and valves.
Area: Silos and transfer houses			
AS/NZS 1680.2.4:2017 [60]	Mine/quarry material handling: general transfer houses, silos/elevators and tipplers	**80**; maintained average	**Direct**
Area: Stockpiles, bins, silos and reclaim facilities			
SANS 10389-1:2003 [12]	Very rough work; short-term handling of large units/raw materials and solid bulk goods	**20**; minimum maintained average	**Direct**
SANS 10389-1:2003 [12]	Rough work; continuous handling of large units/raw materials, freight loading/ unloading and open loading platforms	**50**; minimum maintained average	**Direct**
EN 12464-2:2024 [59]	Short-term handling/loading of large units and raw materials	**20**; maintained average	**Direct**
EN 12464-2:2024 [59]	Continuous handling/ loading of large units and raw materials	**50**; maintained average	**Direct**
DGMS Circular 03/2017 [42]	Loading/unloading/transfer, dumps and ore-stack yards	**15 H; 15 V**; source minimum; H horizontal / V vertical	**Direct**
Area: Tailings and residue installations			
EN 12464-2:2024 [59]	Water/sewage plant: manual valves, motor start/ stop, piping and raking	**50**; conditional **75**; maintained average; source context modifiers apply	**Comparable** — Water-treatment/ power/chemical tasks applied to tailings/return-water work.
EN 12464-2:2024 [59]	Water/sewage plant: chemical handling, leaks, pump changes, service and instruments	**100**; conditional **150**; maintained average; source context modifiers apply	**Comparable** — Water-treatment/ power/chemical tasks applied to tailings/return-water work.
SANS 10114-1:2020 [11]	Power-station pump houses/rooms and water-treatment plant	**150**; maintained average	**Comparable** — Water-treatment/ power/chemical tasks applied to tailings/return-water work.

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W4 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
ISO/CIE 8995-1:2025 [23]	Power-station side rooms, including pump rooms and switchboards	**200**; conditional **300**; maintained average; source context modifiers apply	**Comparable** — Water-treatment/ power/chemical tasks applied to tailings/return-water work.
AS/NZS 1680.2.4:2017 [60]	Petroleum/chemical pump/ compressor houses and permanently occupied process workstations	**160**; maintained average	**Comparable** — Water-treatment/ power/chemical tasks applied to tailings/return-water work.
Area: Thickening, filtration and dewatering areas			
SANS 10114-1:2020 [11]	Preparation plants, work areas	**200**; maintained average E_m; table minimum required level	**Direct** — General preparation-process operations.
AS/NZS 1680.2.4:2017 [60]	Mine/quarry lamp rooms, attended material handling/ sampling/bagging, preparation plants and winding houses	**160**; maintained average	**Direct** — General preparation-process operations.
DGMS Circular 03/2017 [42]	Mineral/ore plant operating points	**50 H**; source minimum; H horizontal / V vertical	**Direct** — General preparation-process operations.
IS 6665:1972 [61]	Coal preparation plant: working areas	**150**; average (Table 2)	**Direct** — General preparation-process operations.
IS 6665:1972 [61]	Chemical works: furnaces, boiling tanks, driers, crystallisers, filtration, extractors and electrolytic cells	**150**; average (Table 2)	**Comparable** — Chemical-works filtration/drying applied to mineral processing.
Area: Truck and rail load-out areas			
SANS 10389-1:2003 [12]	Very rough work; short-term handling of large units/raw materials and solid bulk goods	**20**; minimum maintained average	**Direct**
SANS 10389-1:2003 [12]	Rough work; continuous handling of large units/raw materials, freight loading/ unloading and open loading platforms	**50**; minimum maintained average	**Direct**
EN 12464-2:2024 [59]	Short-term handling/loading of large units and raw materials	**20**; maintained average	**Direct**
EN 12464-2:2024 [59]	Continuous handling/ loading of large units and raw materials	**50**; maintained average	**Direct**
DGMS Circular 03/2017 [42]	Loading/unloading/transfer, dumps and ore-stack yards	**15 H; 15 V**; source minimum; H horizontal / V vertical	**Direct**
IS 6665:1972 [61]	Coal unloading areas	**20**; average (Table 2)	**Comparable** — Power-station coal unloading applied to bulk load-out.

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W4 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
SANS 10114-1:2020 [11]	Loading ramps/bays	**150**; maintained average	**Direct**
ISO/CIE 8995-1:2025 [23]	Loading ramps/bays	**150**; conditional **200**; maintained average; source context modifiers apply	**Direct**
AS/NZS 1680.2.1:2008 [62]	Loading bays	**80**; maintained average	**Direct**
ANSI/IES RP-7-21+E1 [16]	Outdoor loading/unloading platforms	**200 H; 100 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**
AS/NZS 1680.2.4:2017 [60]	Mine/quarry conveyors, gantries and wagon loading/ unloading: movement/ orientation	**40**; maintained average	**Direct**
Area: Washing, scrubbing and sorting areas			
SANS 10114-1:2020 [11]	Preparation plants, work areas	**200**; maintained average E_m; table minimum required level	**Direct** — Indoor preparation work and coarse raw-material cleaning/ sorting.
AS/NZS 1680.2.4:2017 [60]	Mine/quarry lamp rooms, attended material handling/ sampling/bagging, preparation plants and winding houses	**160**; maintained average	**Direct** — Indoor preparation work and coarse raw-material cleaning/ sorting.
ANSI/IES RP-7-21+E1 [16]	Coarse raw-material cleaning/cutting/crushing/ sorting/grading	**100 H; 100 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct** — Indoor preparation work and coarse raw-material cleaning/ sorting.
ANSI/IES RP-7-21+E1 [16]	Medium raw-material processing	**300 H; 300 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Comparable** — Medium/fine material-processing reference for washing, scrubbing and sorting.

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W4 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
ANSI/IES RP-7-21+E1 [16]	Fine raw-material processing	**500 H; 500 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Comparable** — Medium/fine material-processing reference for washing, scrubbing and sorting.
IS 6665:1972 [61]	Coal preparation plant: working areas	**150**; average (Table 2)	**Direct** — Indoor preparation work and coarse raw-material cleaning/ sorting.

Shared and supporting facilities - Common and supporting workplaces

Table 33: W4 - Shared and supporting facilities - Common and supporting workplaces.

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Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Conveyor transfer points, drives and tail ends			
SANS 10114-1:2020 [11]	Pulverisers, crushers, screens, feeder points, transfer areas	**100**; maintained average E_m; table minimum required level	**Direct**
AS/NZS 1680.2.4:2017 [60]	Mine/quarry material handling: general transfer houses, silos/elevators and tipplers	**80**; maintained average	**Direct**
DGMS Circular 03/2017 [42]	Conveyor transfer and drive/ tail-end areas	**40 H**; source minimum; H horizontal / V vertical	**Direct**
SIM 160701: earlier framework summary [9]	Surface/underground conveyor transfer points	**40 H**; historical development-stage summary	**Direct** — Conveyor/transfer task in the same setting.
Area: Opencast conveyor routes			
DGMS Circular 03/2017 [42]	Along conveyors	**20 H**; source minimum; H horizontal / V vertical	**Direct**
SIM 160701: earlier framework summary [9]	Along surface/underground conveyor	**20 H**; historical development-stage summary	**Direct** — Conveyor/transfer task in the same setting.
Area: Outdoor conveyors			
IS 6665:1972 [61]	Conveyors	**50**; average (Table 2)	**Comparable** — Power-station outdoor conveyor reference applied to mine conveyors.

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W4 - Shared and supporting facilities - Common and supporting workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Outdoor process conveyors and crossings			
SANS hazardous-process task class.			
SANS 10389-1:2003 [12]	Hazardous industries: medium-risk areas, including conveyors	**20**; maintained horizontal average	**Direct**
SANS 10389-1:2003 [12]	Hazardous industries: high-risk pumps, valves, platforms, regular stairs and conveyor crossings	**50**; maintained horizontal average	**Direct**
Area: Surface and plant crushers, screens and feeders			
SANS 10114-1:2020 [11]	Pulverisers, crushers, screens, feeder points, transfer areas	**100**; maintained average E_m; table minimum required level	**Direct**
DGMS Circular 03/2017 [42]	Mineral/ore plant crushing, screening, segregation and loading/unloading	**40 H**; source minimum; H horizontal / V vertical	**Direct**
AS/NZS 1680.2.4:2017 [60]	Mine/quarry lamp rooms, attended material handling/ sampling/bagging, preparation plants and winding houses	**160**; maintained average	**Direct** — General preparation-plant work and attended material handling.
ANSI/IES RP-7-21+E1 [16]	Coarse raw-material cleaning/cutting/crushing/ sorting/grading	**100 H; 100 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct** — Coarse raw-material crushing/sorting.
DGMS Circular 03/2017 [42]	Mineral/ore plant operating points	**50 H**; source minimum; H horizontal / V vertical	**Direct**
SANS 10114-1:2020 [11]	Preparation plants, work areas	**200**; maintained average E_m; table minimum required level	**Direct** — General indoor preparation-plant work.
AS/NZS 1680.2.4:2017 [60]	Mine/quarry lamp rooms, attended material handling/ sampling/bagging, preparation plants and winding houses	**160**; maintained average	**Direct** — General indoor preparation-plant work.
IS 6665:1972 [61]	Coal preparation plant: working areas	**150**; average (Table 2)	**Direct** — General indoor preparation-plant work.
IS 6665:1972 [61]	Coal preparation plant: other areas	**100**; average (Table 2)	**Direct**
DGMS Circular 03/2017 [42]	Other mineral/ore plant areas	**20 H**; source minimum; H horizontal / V vertical	**Direct**

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A.5 W5 - Maintenance, fabrication and inspection

Underground - Static workplaces

Table 34: W5 - Underground - Static workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Isolated crusher-maintenance and blockage-clearance workplaces			
ANSI/IES RP-7-21+E1 [16]	Maintenance	**500 H; 150 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Comparable** — Maintenance reference for blockage-clearance work.
SANS 10114-1:2020 [11]	Rough/average machining, tolerances greater than 0.1 mm	**300**; maintained average	**Weak** — Precision-machining reference.
ISO/CIE 8995-1:2025 [23]	Rough/average machining, tolerance at least 0.1 mm	**300**; conditional **500**; maintained average; source context modifiers apply	**Weak** — Precision-machining reference.
Area: Underground workshops			
MVSSA Data Book [10]	Workshops - major maintenance	**400**; minimum; grid/ statistic unspecified	**Direct**
MVSSA Data Book [10]	Workshops - service only	**200**; minimum; grid/ statistic unspecified	**Direct**
MT/T 1248:2025 [58]	Equipment changeover chambers, repair rooms, dispatch rooms and signal stations	**75**; table minimum; averaging unspecified	**Direct**
ANSI/IES RP-7-21+E1 [16]	Maintenance	**500 H; 150 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct** — Industrial maintenance in an enclosed mine workshop.
SANS 10114-1:2020 [11]	Rough/average machining, tolerances greater than 0.1 mm	**300**; maintained average	**Direct** — Machining/inspection at the published tolerance or detail class.
ISO/CIE 8995-1:2025 [23]	Rough/average machining, tolerance at least 0.1 mm	**300**; conditional **500**; maintained average; source context modifiers apply	**Direct** — Machining/inspection at the published tolerance or detail class.

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W5 - Underground - Static workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
ANSI/IES RP-7-21+E1 [16]	Rough bench or machine work	**300 H; 300 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct** — Machining/inspection at the published tolerance or detail class.
IS 6665:1972 [61]	Rough bench and machine work	**150**; average (Table 2)	**Direct** — Machining/inspection at the published tolerance or detail class.
SANS 10114-1:2020 [11]	Precision machining/ grinding, tolerances less than 0.1 mm	**500**; maintained average	**Direct** — Machining/inspection at the published tolerance or detail class.
SANS 10114-1:2020 [11]	Scribing and inspection	**750**; maintained average	**Direct** — Machining/inspection at the published tolerance or detail class.
ISO/CIE 8995-1:2025 [23]	Precision machining/ grinding, tolerance at most 0.1 mm	**500**; conditional **750**; maintained average; source context modifiers apply	**Direct** — Machining/inspection at the published tolerance or detail class.
ISO/CIE 8995-1:2025 [23]	Scribing and inspection	**750**; conditional **1000**; maintained average; source context modifiers apply	**Direct** — Machining/inspection at the published tolerance or detail class.
ANSI/IES RP-7-21+E1 [16]	Fine bench/machine work or fine grinding	**3000 H; 3000 V**; maintained horizontal/ vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Comparable** — Fine bench/ machine-work reference.
IS 6665:1972 [61]	Fine bench/machine work and fine automatic machines	**700**; average (Table 2)	**Comparable** — Fine bench/ machine-work reference.
IS 6665:1972 [61]	Fine inspection: calibrated scales, precision mechanisms and instruments	**700**; average (Table 2)	**Direct** — Parts/instrument inspection by rough, medium or fine detail class.
IS 6665:1972 [61]	Rough inspection: counting / rough checking stock parts	**150**; average (Table 2)	**Direct** — Parts/instrument inspection by rough, medium or fine detail class.
IS 6665:1972 [61]	Medium inspection: go/ no-go gauges and subassemblies	**300**; average (Table 2)	**Direct** — Parts/instrument inspection by rough, medium or fine detail class.
ISO/CIE 8995-1:2025 [23]	Fine assembly	**500**; conditional **750**; maintained average; source context modifiers apply	**Direct** — Fine assembly at an indoor workshop bench.

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Processing - Plant workplaces

Table 35: W5 - Processing - Plant workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Process-water pump and motor-repair workplaces			
EN 12464-2:2024 [59]	Water/sewage plant: motor/ electrical repair	**200**; conditional **300**; maintained average; source context modifiers apply	**Comparable** — Water-treatment/ power/chemical tasks applied to tailings/return-water work.
SANS 10389-1:2003 [12]	Hazardous industries: machine/electrical repair	**200**; maintained horizontal average	**Comparable** — Water-treatment/ power/chemical tasks applied to tailings/return-water work.
Area: Tailings-pump and motor-repair workplaces			
EN 12464-2:2024 [59]	Water/sewage plant: motor/ electrical repair	**200**; conditional **300**; maintained average; source context modifiers apply	**Comparable** — Water-treatment/ power/chemical tasks applied to tailings/return-water work.
SANS 10389-1:2003 [12]	Hazardous industries: machine/electrical repair	**200**; maintained horizontal average	**Comparable** — Water-treatment/ power/chemical tasks applied to tailings/return-water work.

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Shared and supporting facilities - Common and supporting workplaces

Table 36: W5 - Shared and supporting facilities - Common and supporting workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: General mine workshops			
DGMS Circular 03/2017 [42]	Workshop	**100 H; 50 V**; source minimum; H horizontal / V vertical	**Direct**
Area: Indoor power-plant maintenance workplaces			
AS/NZS 1680.2.4:2017 [60]	Electricity-generating plant areas: maintenance	**320**; maintained average	**Weak** — Indoor electricity-generation plant-maintenance reference.
Area: Machining and fitting workshops			
SANS 10114-1:2020 [11]	Rough/average machining, tolerances greater than 0.1 mm	**300**; maintained average	**Direct** — Machining/inspection at the published tolerance or detail class.

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W5 - Shared and supporting facilities - Common and supporting workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
ISO/CIE 8995-1:2025 [23]	Rough/average machining, tolerance at least 0.1 mm	**300**; conditional **500**; maintained average; source context modifiers apply	**Direct** — Machining/inspection at the published tolerance or detail class.
ANSI/IES RP-7-21+E1 [16]	Rough bench or machine work	**300 H; 300 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct** — Machining/inspection at the published tolerance or detail class.
IS 6665:1972 [61]	Rough bench and machine work	**150**; average (Table 2)	**Direct** — Machining/inspection at the published tolerance or detail class.
Area: Machining and inspection workshops			
SANS 10114-1:2020 [11]	Precision machining/ grinding, tolerances less than 0.1 mm	**500**; maintained average	**Direct** — Machining/inspection at the published tolerance or detail class.
SANS 10114-1:2020 [11]	Scribing and inspection	**750**; maintained average	**Direct** — Machining/inspection at the published tolerance or detail class.
ISO/CIE 8995-1:2025 [23]	Precision machining/ grinding, tolerance at most 0.1 mm	**500**; conditional **750**; maintained average; source context modifiers apply	**Direct** — Machining/inspection at the published tolerance or detail class.
ISO/CIE 8995-1:2025 [23]	Scribing and inspection	**750**; conditional **1000**; maintained average; source context modifiers apply	**Direct** — Machining/inspection at the published tolerance or detail class.
ANSI/IES RP-7-21+E1 [16]	Fine bench/machine work or fine grinding	**3000 H; 3000 V**; maintained horizontal/ vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Comparable** — Fine bench/ machine-work reference.
IS 6665:1972 [61]	Fine bench/machine work and fine automatic machines	**700**; average (Table 2)	**Comparable** — Fine bench/ machine-work reference.
IS 6665:1972 [61]	Fine inspection: calibrated scales, precision mechanisms and instruments	**700**; average (Table 2)	**Direct** — Parts/instrument inspection by rough, medium or fine detail class.
Area: Outdoor cleaning and servicing workplaces			
EN 12464-2:2024 [59]	Cleaning and servicing	**50**; maintained average	**Direct**

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W5 - Shared and supporting facilities - Common and supporting workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Outdoor electrical-repair workplaces			
SANS 10389-1:2003 [12]	Power plants: electrical repair	**200**; maintained horizontal average	**Direct**
EN 12464-2:2024 [59]	Power plants: electrical repair	**200**; conditional **300**; maintained average; source context modifiers apply	**Direct**
Area: Outdoor field-maintenance workplaces			
SANS 10389-1:2003 [12]	Fine work; demanding electrical, machine and piping installation and inspection	**200**; minimum maintained average	**Direct**
EN 12464-2:2024 [59]	Demanding electrical/ machine/piping installation and inspection	**200**; maintained average	**Direct**
SANS 10389-1:2003 [12]	Hazardous industries: machine/electrical repair	**200**; maintained horizontal average	**Comparable** — Hazardous/ chemical-process machine and electrical repair applied to field maintenance.
EN 12464-2:2024 [59]	Chemical industries: machine/electrical repair	**200**; conditional **300**; maintained average; source context modifiers apply	**Comparable** — Hazardous/ chemical-process machine and electrical repair applied to field maintenance.
Area: Outdoor installation and repair workplaces			
SANS 10389-1:2003 [12]	Building-site accurate mounting, piping and cabling	**100**; maintained horizontal average	**Comparable** — Construction mounting, piping, cabling and repair applied to mine installations.
SANS 10389-1:2003 [12]	Building-site demanding electrical/machine/pipe work	**200**; maintained horizontal average	**Comparable** — Construction mounting, piping, cabling and repair applied to mine installations.
EN 12464-2:2024 [59]	Building-site demanding electrical/machine/pipe mounting	**200**; conditional **300**; maintained average; source context modifiers apply	**Comparable** — Construction mounting, piping, cabling and repair applied to mine installations.
Area: Parts-inspection workplaces			
IS 6665:1972 [61]	Rough inspection: counting / rough checking stock parts	**150**; average (Table 2)	**Direct** — Parts/instrument inspection by rough, medium or fine detail class.
IS 6665:1972 [61]	Medium inspection: go/ no-go gauges and subassemblies	**300**; average (Table 2)	**Direct** — Parts/instrument inspection by rough, medium or fine detail class.
Area: Servicing workbenches			
SANS 10114-1:2020 [11]	Vehicle-servicing workbenches	**400**; maintained average	**Direct**

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W5 - Shared and supporting facilities - Common and supporting workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
SANS 10114-1:2020 [11]	Rough bench and machine work	**200**; maintained average	**Direct** — Servicing-bench/ machine work at the published detail class.
SANS 10114-1:2020 [11]	Medium bench and machine work; rough grinding/buffing/polishing	**400**; maintained average	**Direct** — Servicing-bench/ machine work at the published detail class.
ANSI/IES RP-7-21+E1 [16]	Rough bench or machine work	**300 H; 300 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct** — Servicing-bench/ machine work at the published detail class.
ANSI/IES RP-7-21+E1 [16]	Medium bench or machine work	**500 H; 500 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct** — Servicing-bench/ machine work at the published detail class.
IS 6665:1972 [61]	Medium bench/machine work, ordinary automatic machines and rough grinding	**300**; average (Table 2)	**Direct** — Servicing-bench/ machine work at the published detail class.
Area: Vehicle-repair bays			
SANS 10114-1:2020 [11]	Vehicle repairs	**350**; maintained average	**Direct**
AS/NZS 1680.2.4:2017 [60]	Garages and service stations: pumps and repair	**400**; maintained average	**Direct**
ISO/CIE 8995-1:2025 [23]	General vehicle service, repair and testing	**500**; conditional **750**; maintained average; source context modifiers apply	**Direct**
ANSI/IES RP-7-21+E1 [16]	Maintenance	**500 H; 150 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct** — Vehicle-repair maintenance at the published H/V basis.
Area: Vehicle-service, wash and lubrication bays			
SANS 10114-1:2020 [11]	Vehicle washing, polishing and greasing bays	**200**; maintained average	**Direct**
SANS 10114-1:2020 [11]	Servicing pits: underside of vehicle	**200**; maintained average	**Direct**

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W5 - Shared and supporting facilities - Common and supporting workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
AS/NZS 1680.2.4:2017 [60]	Vehicle general servicing, greasing, pits, washing and polishing	**240**; maintained average	**Direct**

Additional named workplaces: evidence gaps

Table 37: W5 - Named workplaces without a dedicated matched comparison record.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
No dedicated matched record in the maintained comparison. Proposal W5; testing	**Equipment-testing workplaces** Shared and supporting facilities	Not located in the current extracted comparison.	**Evidence gap.** Source identification and task matching pending.
No dedicated matched record in the maintained comparison. Proposal W5; fabrication	**Fabrication workplaces** Shared and supporting facilities	Not located in the current extracted comparison.	**Evidence gap.** Source identification and task matching pending.
No dedicated matched record in the maintained comparison. Existing area register and task inventory	**Tyre-servicing bays** Shared and supporting facilities	Not located in the current extracted comparison.	**Evidence gap.** Source identification and task matching pending.
No dedicated matched record in the maintained comparison. Proposal W5; welding	**Welding workplaces** Shared and supporting facilities	Not located in the current extracted comparison.	**Evidence gap.** Source identification and task matching pending.

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A.6 W6 - Utilities, storage and servicing

Underground - Static workplaces

Table 38: W6 - Underground - Static workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: General underground service and equipment rooms			
Historical 160–400 range attributed to MVS guidance.			
GAP 804 [2]	Underground service/ equipment rooms; offices/ classrooms/meeting places	**160-400**; historical recommendation	**Direct**
GAP 804 [2]	Underground service/ equipment rooms; offices/ classrooms/meeting places	**160-400**; historical recommendation	**Direct**
MT/T 1248:2025 [58]	General electromechanical and equipment chambers	**50**; table minimum; averaging unspecified	**Direct**
Area: Permanent fan chambers above 50 kW			
MVSSA Data Book [10]	Fan chambers - permanent, in excess of 50 kW	**100**; minimum; grid/ statistic unspecified	**Direct**
MT/T 1248:2025 [58]	General electromechanical and equipment chambers	**50**; table minimum; averaging unspecified	**Comparable** — Underground equipment-chamber reference for fan/refrigeration rooms.
SANS 10114-1:2020 [11]	Lamp rooms, weighing cabins, fan houses	**200**; maintained average E_m; table minimum required level	**Comparable** — Surface fan-house reference applied to underground fan chambers.
IS 6665:1972 [61]	Fan houses	**100**; average (Table 2)	**Comparable** — Surface fan-house reference applied to underground fan chambers.
Area: Refrigeration plantrooms			
MVSSA Data Book [10]	Refrigeration plantrooms	**100**; minimum; grid/ statistic unspecified	**Direct**
MT/T 1248:2025 [58]	General electromechanical and equipment chambers	**50**; table minimum; averaging unspecified	**Comparable** — Underground equipment-chamber reference for fan/refrigeration rooms.
SANS 10114-1:2020 [11]	Plant rooms and switchgear rooms	**200**; maintained average	**Direct** — General refrigeration plant-room lighting.
ISO/CIE 8995-1:2025 [23]	Plant rooms and switchgear rooms	**200**; conditional **300**; maintained average; source context modifiers apply	**Direct** — General refrigeration plant-room lighting.
AS/NZS 1680.2.1:2008 [62]	Plant rooms: general	**80**; maintained average	**Comparable** — Building plant-room reference applied to underground refrigeration.

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W6 - Underground - Static workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Underground battery-charging stations			
MVSSA Data Book [10]	Battery charging bays	**100**; minimum; grid/ statistic unspecified	**Direct**
MT/T 1248:2025 [58]	General electromechanical and equipment chambers	**50**; table minimum; averaging unspecified	**Comparable** — Underground equipment-chamber lighting for the battery room.
IS 6665:1972 [61]	Battery rooms, blowers, auxiliary generators, switchgear and transformer chambers	**100**; average (Table 2)	**Comparable** — Power-station battery/electrical-room reference applied underground.
Area: Underground explosives-issue rooms			
MT/T 1248:2025 [58]	Fully mechanised coal face, mobile substations and explosive-issue rooms	**30**; table minimum; averaging unspecified	**Direct**
Area: Underground explosives-storage rooms			
MT/T 1248:2025 [58]	Waiting rooms, refuge places, fire-material stores and explosive-storage rooms	**20**; table minimum; averaging unspecified	**Direct**
Area: Underground fuel-storage bays			
GAP 804 [2]	Fuel-filling area	**50**; historical minimum recommendation	**Direct** — Underground fuel dispensing.
Area: Underground pump chambers			
MVSSA Data Book [10]	Pump chambers	**100**; minimum; grid/ statistic unspecified	**Direct**
MT/T 1248:2025 [58]	Main substation and main drainage pump room	**75**; table minimum; averaging unspecified	**Direct**
SANS 10114-1:2020 [11]	Power-station pump houses/rooms and water-treatment plant	**150**; maintained average	**Comparable** — Power/water pump-room reference applied to underground pumping.
ISO/CIE 8995-1:2025 [23]	Power-station side rooms, including pump rooms and switchboards	**200**; conditional **300**; maintained average; source context modifiers apply	**Comparable** — Power/water pump-room reference applied to underground pumping.
Area: Underground refuelling bays			
GAP 804 [2]	Fuel-filling area	**50**; historical minimum recommendation	**Direct**
SANS 10114-1:2020 [11]	Fuel pumps	**200**; maintained average	**Comparable** — Interior vehicle-service fuel-pump reference applied to underground dispensing.

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W6 - Underground - Static workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Underground substations and switchgear rooms			
MVSSA Data Book [10]	Main sub-stations	**100**; minimum; grid/ statistic unspecified	**Direct**
MVSSA Data Book [10]	Switchgear rooms and sites	**100**; minimum; grid/ statistic unspecified	**Direct**
MT/T 1248:2025 [58]	Main substation and main drainage pump room	**75**; table minimum; averaging unspecified	**Direct**
MT/T 1248:2025 [58]	General electromechanical and equipment chambers	**50**; table minimum; averaging unspecified	**Direct**
SANS 10114-1:2020 [11]	Plant rooms and switchgear rooms	**200**; maintained average	**Direct** — General enclosed plant/ switchgear-room lighting.
SANS 10114-1:2020 [11]	Switch houses and rooms; indoor high-voltage substations	**200**; maintained average	**Comparable** — Building/plant electrical work applied to an underground chamber.
ISO/CIE 8995-1:2025 [23]	Plant rooms and switchgear rooms	**200**; conditional **300**; maintained average; source context modifiers apply	**Direct** — General enclosed plant/ switchgear-room lighting.
AS/NZS 1680.2.1:2008 [62]	Plant rooms: general	**80**; maintained average	**Comparable** — Building/plant electrical work applied to an underground chamber.
AS/NZS 1680.2.1:2008 [62]	Plant-room control panels and switchboards	**160**; maintained average; in the panel plane	**Comparable** — Building/plant electrical work applied to an underground chamber.
IS 6665:1972 [61]	Battery rooms, blowers, auxiliary generators, switchgear and transformer chambers	**100**; average (Table 2)	**Comparable** — Power-station battery/electrical-room reference applied underground.
IS 6665:1972 [61]	Switch houses	**150**; average (Table 2)	**Comparable** — Power-station battery/electrical-room reference applied underground.
MVSSA Data Book [10]	Main sub-stations	**100**; minimum; grid/ statistic unspecified	**Direct**
MVSSA Data Book [10]	Switchgear rooms and sites	**100**; minimum; grid/ statistic unspecified	**Direct**
MT/T 1248:2025 [58]	Main substation and main drainage pump room	**75**; table minimum; averaging unspecified	**Direct**
MT/T 1248:2025 [58]	General electromechanical and equipment chambers	**50**; table minimum; averaging unspecified	**Direct**
SANS 10114-1:2020 [11]	Plant rooms and switchgear rooms	**200**; maintained average	**Direct** — General enclosed plant/ switchgear-room lighting.
SANS 10114-1:2020 [11]	Switch houses and rooms; indoor high-voltage substations	**200**; maintained average	**Comparable** — Building/plant electrical work applied to an underground chamber.

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W6 - Underground - Static workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
ISO/CIE 8995-1:2025 [23]	Plant rooms and switchgear rooms	**200**; conditional **300**; maintained average; source context modifiers apply	**Direct** — General enclosed plant/ switchgear-room lighting.
AS/NZS 1680.2.1:2008 [62]	Plant rooms: general	**80**; maintained average	**Comparable** — Building/plant electrical work applied to an underground chamber.
AS/NZS 1680.2.1:2008 [62]	Plant-room control panels and switchboards	**160**; maintained average; in the panel plane	**Comparable** — Building/plant electrical work applied to an underground chamber.
IS 6665:1972 [61]	Battery rooms, blowers, auxiliary generators, switchgear and transformer chambers	**100**; average (Table 2)	**Comparable** — Power-station battery/electrical-room reference applied underground.
IS 6665:1972 [61]	Switch houses	**150**; average (Table 2)	**Comparable** — Power-station battery/electrical-room reference applied underground.

Surface - Surface workplaces

Table 39: W6 - Surface - Surface workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Sumps and dewatering installations			
DGMS Circular 03/2017 [42]	Pumping station	**40 H**; source minimum; H horizontal / V vertical	**Direct**
EN 12464-2:2024 [59]	Water/sewage plant: manual valves, motor start/ stop, piping and raking	**50**; conditional **75**; maintained average; source context modifiers apply	**Comparable** — Water-treatment/ power-plant valve, pump and instrument tasks applied to mine dewatering.
EN 12464-2:2024 [59]	Water/sewage plant: chemical handling, leaks, pump changes, service and instruments	**100**; conditional **150**; maintained average; source context modifiers apply	**Comparable** — Water-treatment/ power-plant valve, pump and instrument tasks applied to mine dewatering.
SANS 10389-1:2003 [12]	Power plants: servicing and instrument reading	**100**; maintained horizontal average	**Comparable** — Water-treatment/ power-plant valve, pump and instrument tasks applied to mine dewatering.
EN 12464-2:2024 [59]	Power plants: servicing and instrument reading	**100**; conditional **150**; maintained average; source context modifiers apply	**Comparable** — Water-treatment/ power-plant valve, pump and instrument tasks applied to mine dewatering.

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Processing - Plant workplaces

Table 40: W6 - Processing - Plant workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Indoor product stores			
SANS 10114-1:2020 [11]	Stores, stockrooms and cold stores	**100**; maintained average	**Direct**
SANS 10114-1:2020 [11]	Stores continuously occupied	**200**; maintained average	**Direct**
ISO/CIE 8995-1:2025 [23]	Store rooms and stockrooms	**100**; conditional **150**; maintained average; source context modifiers apply	**Direct**
ISO/CIE 8995-1:2025 [23]	Continuously occupied store rooms	**200**; maintained average	**Direct**
ANSI/IES RP-7-21+E1 [16]	Inactive storage	**50 H; 20 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**
ANSI/IES RP-7-21+E1 [16]	Active bulky storage, large labels	**100 H; 50 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**
ANSI/IES RP-7-21+E1 [16]	Active small-item storage, small labels	**300 H; 150 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**
Area: Process and return-water installations			
EN 12464-2:2024 [59]	Water/sewage plant: manual valves, motor start/stop, piping and raking	**50**; conditional **75**; maintained average; source context modifiers apply	**Comparable** — Water-treatment/power/chemical tasks applied to tailings/return-water work.
EN 12464-2:2024 [59]	Water/sewage plant: chemical handling, leaks, pump changes, service and instruments	**100**; conditional **150**; maintained average; source context modifiers apply	**Comparable** — Water-treatment/power/chemical tasks applied to tailings/return-water work.

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W6 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
SANS 10114-1:2020 [11]	Power-station pump houses/rooms and water-treatment plant	**150**; maintained average	**Comparable** — Water-treatment/ power/chemical tasks applied to tailings/return-water work.
ISO/CIE 8995-1:2025 [23]	Power-station side rooms, including pump rooms and switchboards	**200**; conditional **300**; maintained average; source context modifiers apply	**Comparable** — Water-treatment/ power/chemical tasks applied to tailings/return-water work.
AS/NZS 1680.2.4:2017 [60]	Petroleum/chemical pump/ compressor houses and permanently occupied process workstations	**160**; maintained average	**Comparable** — Water-treatment/ power/chemical tasks applied to tailings/return-water work.
Area: Reagent stores and issue facilities			
SANS 10114-1:2020 [11]	Stores, stockrooms and cold stores	**100**; maintained average	**Direct** — Ordinary stockroom/ issue-counter work.
SANS 10114-1:2020 [11]	Stores continuously occupied	**200**; maintained average	**Direct** — Ordinary stockroom/ issue-counter work.
ISO/CIE 8995-1:2025 [23]	Store rooms and stockrooms	**100**; conditional **150**; maintained average; source context modifiers apply	**Direct** — Ordinary stockroom/ issue-counter work.
ISO/CIE 8995-1:2025 [23]	Continuously occupied store rooms	**200**; maintained average	**Direct** — Ordinary stockroom/ issue-counter work.
AS/NZS 1680.2.1:2008 [62]	Store counters: intermittent tasks	**240**; maintained average	**Direct** — Ordinary stockroom/ issue-counter work.

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Shared and supporting facilities - Common and supporting workplaces

Table 41: W6 - Shared and supporting facilities - Common and supporting workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Air, water and vehicle-service points			
SANS 10389-1:2003 [12]	Filling-station air/water checking and other service areas	**75-150**; maintained horizontal average	**Direct**
EN 12464-2:2024 [59]	Fuel stations: air/water checking and other service areas	**150**; maintained average	**Direct**
Area: Bulk fuel loading and unloading areas			
SANS 10389-1:2003 [12]	Fuel loading and unloading	**100**; maintained horizontal average	**Direct**

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W6 - Shared and supporting facilities - Common and supporting workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
EN 12464-2:2024 [59]	Fuel loading and unloading	**100**; conditional **150**; maintained average; source context modifiers apply	**Direct**
Area: Compressor rooms			
AS/NZS 1680.2.4:2017 [60]	Petroleum/chemical pump/ compressor houses and permanently occupied process workstations	**160**; maintained average	**Comparable** — Petroleum/ chemical pump and compressor-house reference for mine compressor rooms.
Area: General stores and stockrooms			
SANS 10114-1:2020 [11]	Stores, stockrooms and cold stores	**100**; maintained average	**Direct**
SANS 10114-1:2020 [11]	Stores continuously occupied	**200**; maintained average	**Direct**
ISO/CIE 8995-1:2025 [23]	Store rooms and stockrooms	**100**; conditional **150**; maintained average; source context modifiers apply	**Direct**
ISO/CIE 8995-1:2025 [23]	Continuously occupied store rooms	**200**; maintained average	**Direct**
AS/NZS 1680.2.4:2017 [60]	Warehouse storage of different goods and search/ retrieval	**80**; maintained average	**Direct**
AS/NZS 1680.2.1:2008 [62]	Rough bulky material: dead storage	**40**; maintained average	**Direct**
AS/NZS 1680.2.1:2008 [62]	Rough bulky material: live storage	**80**; maintained average	**Direct**
AS/NZS 1680.2.1:2008 [62]	Medium/fine material: dead storage	**80**; maintained average	**Direct**
AS/NZS 1680.2.1:2008 [62]	Medium/fine material: live storage	**160**; maintained average	**Direct**
ANSI/IES RP-7-21+E1 [16]	Inactive storage	**50 H; 20 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**
ANSI/IES RP-7-21+E1 [16]	Active bulky storage, large labels	**100 H; 50 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**

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W6 - Shared and supporting facilities - Common and supporting workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
ANSI/IES RP-7-21+E1 [16]	Active small-item storage, small labels	**300 H; 150 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**
AS/NZS 1680.2.4:2017 [60]	Storage with routine reading; large-object packing/dispatch/wrapping/ labelling	**160**; maintained average	**Direct**
AS/NZS 1680.2.1:2008 [62]	Store counters: intermittent tasks	**240**; maintained average	**Direct**
AS/NZS 1680.2.1:2008 [62]	Store counters: sustained tasks	**320**; maintained average	**Direct**
Area: Lamp rooms			
SANS 10114-1:2020 [11]	Lamp rooms, weighing cabins, fan houses	**200**; maintained average E_m; table minimum required level	**Direct**
AS/NZS 1680.2.4:2017 [60]	Mine/quarry lamp rooms, attended material handling/ sampling/bagging, preparation plants and winding houses	**160**; maintained average	**Direct**
IS 6665:1972 [61]	Lamp rooms: main areas	**100**; average (Table 2)	**Direct**
IS 6665:1972 [61]	Lamp rooms: repair sections	**150**; average (Table 2)	**Direct**
Area: Mine pumping stations			
DGMS Circular 03/2017 [42]	Pumping station	**40 H**; source minimum; H horizontal / V vertical	**Direct**
Area: Outdoor substations and switchyards			
DGMS Circular 03/2017 [42]	Electrical substation	**100 H; 50 V**; source minimum; H horizontal / V vertical	**Direct**
SANS 10389-1:2003 [12]	Power plants: high-risk switchyards	**50 H; 50 V**; maintained horizontal average and vertical average	**Direct**
DGMS Circular 03/2017 [42]	Other electrical-apparatus operating places	**20 H; 20 V**; source minimum; H horizontal / V vertical	**Direct**

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W6 - Shared and supporting facilities - Common and supporting workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Outdoor vehicle-charging stations			
EN 12464-2:2024 [59]	Car charging points in lit areas	**20**; maintained average	**Comparable** — Vehicle-charging reference for connections and display reading.
EN 12464-2:2024 [59]	Car charging points in unlit areas	**10**; maintained average	**Comparable** — Vehicle-charging reference for connections and display reading.
EN 12464-2:2024 [59]	Non-self-lit car-charger display during reading	**50**; vertical maintained average	**Comparable** — Vehicle-charging reference for connections and display reading.
Area: Surface explosives magazines and issue facilities			
MT/T 1248:2025 [58]	Waiting rooms, refuge places, fire-material stores and explosive-storage rooms	**20**; table minimum; averaging unspecified	**Comparable** — Underground-coal explosives storage/issue reference applied to a surface magazine.
MT/T 1248:2025 [58]	Fully mechanised coal face, mobile substations and explosive-issue rooms	**30**; table minimum; averaging unspecified	**Comparable** — Underground-coal explosives storage/issue reference applied to a surface magazine.
SANS 10114-1:2020 [11]	Stores, stockrooms and cold stores	**100**; maintained average	**Direct** — Indoor explosives storage/issue-counter lighting.
SANS 10114-1:2020 [11]	Stores continuously occupied	**200**; maintained average	**Direct** — Indoor explosives storage/issue-counter lighting.
ISO/CIE 8995-1:2025 [23]	Store rooms and stockrooms	**100**; conditional **150**; maintained average; source context modifiers apply	**Direct** — Indoor explosives storage/issue-counter lighting.
ISO/CIE 8995-1:2025 [23]	Continuously occupied store rooms	**200**; maintained average	**Direct** — Indoor explosives storage/issue-counter lighting.
AS/NZS 1680.2.1:2008 [62]	Store counters: intermittent tasks	**240**; maintained average	**Direct** — Indoor explosives storage/issue-counter lighting.
AS/NZS 1680.2.1:2008 [62]	Store counters: sustained tasks	**320**; maintained average	**Direct** — Indoor explosives storage/issue-counter lighting.
Area: Surface fuel-filling and meter-reading points			
SANS 10389-1:2003 [12]	Filling-station meter reading: dark environment	**150-300**; maintained horizontal average	**Direct**
EN 12464-2:2024 [59]	Fuel stations: meter reading	**150**; maintained average	**Direct**
Area: Utility instrument-reading and servicing positions			
SANS 10389-1:2003 [12]	Power plants: overall inspection	**50**; maintained horizontal average	**Direct**
SANS 10389-1:2003 [12]	Power plants: servicing and instrument reading	**100**; maintained horizontal average	**Direct**

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W6 - Shared and supporting facilities - Common and supporting workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
EN 12464-2:2024 [59]	Power plants: overall inspection	**50**; conditional **75**; maintained average; source context modifiers apply	**Direct**
EN 12464-2:2024 [59]	Power plants: servicing and instrument reading	**100**; conditional **150**; maintained average; source context modifiers apply	**Direct**

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A.7 W7 - Control, laboratory and administrative work

Underground - Static workplaces

Table 42: W7 - Underground - Static workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Winder and hoist operating positions			
GAP 804 [2]	Rope coiling at winding drum	**160**; historical recommendation	**Direct**
GAP 804 [2]	Position indicators, ammeters and gauges	**160**; historical minimum recommendation	**Direct**
Area: Winder and hoist rooms			
MVSSA Data Book [10]	Winder and hoist rooms	**20**; minimum; grid/ statistic unspecified	**Direct**
SANS 10114-1:2020 [11]	Winding houses	**200**; maintained average E_m; table minimum required level	**Comparable** — Surface winding-house reference applied to underground winding.
AS/NZS 1680.2.4:2017 [60]	Mine/quarry lamp rooms, attended material handling/ sampling/bagging, preparation plants and winding houses	**160**; maintained average	**Comparable** — Surface winding-house reference applied to underground winding.
IS 6665:1972 [61]	Winding houses	**150**; average (Table 2)	**Comparable** — Surface winding-house reference applied to underground winding.

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Surface - Surface workplaces

Table 43: W7 - Surface - Surface workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Survey and geotechnical instrument stations			
SANS 10389-1:2003 [12]	Accurate work; address reading, covered loading platforms and ordinary tool work	**100**; minimum maintained average	**Weak** — Local tool/ instrument-reading reference.
EN 12464-2:2024 [59]	Address reading, tools and ordinary reinforcement/ casting work	**100**; maintained average	**Weak** — Local tool/ instrument-reading reference.
SANS 10389-1:2003 [12]	Power plants: servicing and instrument reading	**100**; maintained horizontal average	**Weak** — Local tool/ instrument-reading reference.

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W7 - Surface - Surface workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
EN 12464-2:2024 [59]	Power plants: servicing and instrument reading	**100**; conditional **150**; maintained average; source context modifiers apply	**Weak** — Local tool/ instrument-reading reference.

Processing - Plant workplaces

Table 44: W7 - Processing - Plant workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Control rooms and local operating stations			
SANS 10114-1:2020 [11]	Control stations	**150**; maintained average	**Direct**
SANS 10114-1:2020 [11]	Control stations continuously occupied	**200**; maintained average	**Direct**
AS/NZS 1680.2.1:2008 [62]	Control/monitoring rooms: intermittently monitored	**240**; maintained average	**Direct**
AS/NZS 1680.2.1:2008 [62]	Control/monitoring rooms: continuously monitored	**320**; maintained average	**Direct**
DGMS Circular 03/2017 [42]	Mineral/ore plant operating points	**50 H**; source minimum; H horizontal / V vertical	**Weak** — Mineral-handling plant operating-point reference.
AS/NZS 1680.2.1:2008 [62]	Plant-room control panels and switchboards	**160**; maintained average; in the panel plane	**Direct**
SANS 10114-1:2020 [11]	Power-station control-room control-panel face	**300 V**; maintained average	**Comparable** — Power/ chemical-sector panel, desk and control-room reference.
SANS 10114-1:2020 [11]	Control desks with display-screen equipment	**400**; maintained average	**Comparable** — Power/ chemical-sector panel, desk and control-room reference.
AS/NZS 1680.2.4:2017 [60]	Electricity-generating plant: normal operation, instruments, gauges and valves	**160**; maintained average	**Comparable** — Power/ chemical-sector panel, desk and control-room reference.
IS 6665:1972 [61]	Chemical control rooms: vertical panels	**200-300 V**; average (Table 2)	**Comparable** — Power/ chemical-sector panel, desk and control-room reference.
IS 6665:1972 [61]	Chemical control rooms: desks	**300**; average (Table 2)	**Comparable** — Power/ chemical-sector panel, desk and control-room reference.
IS 6665:1972 [61]	Control rooms: vertical panels	**200-300 V**; average (Table 2)	**Comparable** — Power/ chemical-sector panel, desk and control-room reference.

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W7 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
IS 6665:1972 [61]	Control desks	**300**; average (Table 2)	**Comparable** — Power/ chemical-sector panel, desk and control-room reference.
ISO/CIE 8995-1:2025 [23]	Power-station control rooms	**500**; conditional **1000**; maintained average; source context modifiers apply	**Comparable** — Power/ chemical-sector panel, desk and control-room reference.
ISO/CIE 8995-1:2025 [23]	Surveillance station	**300**; conditional **500**; maintained average; source context modifiers apply	**Direct**
Conditional emergency-lighting value.			
SANS 10114-2:2020 [43]	High-risk tasks during emergency	**20 or 10% of normal task illuminance, whichever is greater**; emergency average horizontal illuminance	**Direct**
Area: Laboratories and assay rooms			
SANS 10114-1:2020 [11]	General laboratories and balance rooms	**500**; maintained average	**Direct**
ISO/CIE 8995-1:2025 [23]	Precision measuring rooms and laboratories	**500**; conditional **750**; maintained average; source context modifiers apply	**Direct**
AS/NZS 1680.2.4:2017 [60]	Laboratories and testing areas	**400**; maintained average	**Direct**
ANSI/IES RP-7-21+E1 [16]	Laboratories: general	**500 H; 300 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**
IS 6665:1972 [61]	General laboratories and balance rooms	**300**; average (Table 2)	**Direct**
ANSI/IES RP-7-21+E1 [16]	Laboratory benches	**1000 H; 500 V**; maintained horizontal/ vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**
SANS 10114-1:2020 [11]	Calibration scales and precision mechanical instruments	**700**; maintained average	**Direct**

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W7 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
AS/NZS 1680.2.4:2017 [60]	Laboratories: calibrated scales, precision mechanisms and instruments	**600**; maintained average	**Direct**
IS 6665:1972 [61]	Fine inspection: calibrated scales, precision mechanisms and instruments	**700**; average (Table 2)	**Direct** — Reading calibrated scales, precision mechanisms and instruments.
Colour-judgement task.			
ISO/CIE 8995-1:2025 [23]	Chemical-industry colour inspection	**1000**; conditional **1500**; maintained average; source context modifiers apply	**Direct**
IS 6665:1972 [61]	Electrical and instrument laboratories	**450**; average (Table 2)	**Direct**
Area: Sampling and sample-preparation workplaces			
AS/NZS 1680.2.4:2017 [60]	Mine/quarry lamp rooms, attended material handling/ sampling/bagging, preparation plants and winding houses	**160**; maintained average	**Direct**
SANS 10114-1:2020 [11]	Preparation plants, work areas	**200**; maintained average E_m; table minimum required level	**Direct** — General sample-preparation work area.
ANSI/IES RP-7-21+E1 [16]	Medium raw-material processing	**300 H; 300 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Comparable** — Medium/fine raw-material processing reference for sample preparation.
ANSI/IES RP-7-21+E1 [16]	Fine raw-material processing	**500 H; 500 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Comparable** — Medium/fine raw-material processing reference for sample preparation.
SANS 10114-1:2020 [11]	General laboratories and balance rooms	**500**; maintained average	**Direct**
ISO/CIE 8995-1:2025 [23]	Precision measuring rooms and laboratories	**500**; conditional **750**; maintained average; source context modifiers apply	**Direct**
AS/NZS 1680.2.4:2017 [60]	Laboratories and testing areas	**400**; maintained average	**Direct**

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W7 - Processing - Plant workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
ANSI/IES RP-7-21+E1 [16]	Laboratories: general	**500 H; 300 V**; maintained horizontal/vertical average targets; baseline: normally sighted people under 65; minimum targets for significant safety/security or human-vehicle proximity	**Direct**
IS 6665:1972 [61]	General laboratories and balance rooms	**300**; average (Table 2)	**Direct**

Shared and supporting facilities - Common and supporting workplaces

Table 45: W7 - Shared and supporting facilities - Common and supporting workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Gatehouses and surveillance stations			
AS/NZS 1680.2.1:2008 [62]	Gatehouses	**160**; maintained average	**Direct**
ISO/CIE 8995-1:2025 [23]	Surveillance station	**300**; conditional **500**; maintained average; source context modifiers apply	**Direct**
Area: Meeting and training rooms			
ISO/CIE 8995-1:2025 [23]	Conference and meeting rooms	**500**; conditional **1000**; maintained average; source context modifiers apply	**Direct**
ISO/CIE 8995-1:2025 [23]	Classrooms: general activities	**500**; conditional **1000**; maintained average; source context modifiers apply	**Direct**
GAP 804 [2]	Underground service/ equipment rooms; offices/ classrooms/meeting places	**160-400**; historical recommendation	**Direct** — Office, classroom and meeting-place lighting.
Area: Office workstations			
SANS 10114-1:2020 [11]	Office writing, reading and data processing	**500**; maintained average	**Direct**
ISO/CIE 8995-1:2025 [23]	Office writing, typing, reading and data processing	**500**; conditional **1000**; maintained average; source context modifiers apply	**Direct**

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W7 - Shared and supporting facilities - Common and supporting workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Teaching and presentation rooms			
ISO/CIE 8995-1:2025 [23]	Black, green and white boards	**500 V**; conditional **750**; maintained average; source context modifiers apply	**Direct**
Area: Weighing cabins and weighbridge controls			
SANS 10114-1:2020 [11]	Lamp rooms, weighing cabins, fan houses	**200**; maintained average E_m; table minimum required level	**Direct**
IS 6665:1972 [61]	Weigh cabins	**150**; average (Table 2)	**Direct**

Additional named workplaces: evidence gaps

Table 46: W7 - Named workplaces without a dedicated matched comparison record.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
No dedicated matched record in the maintained comparison. Current classification; CPU rooms	**CPU and computing rooms** Surface	Not located in the current extracted comparison.	**Evidence gap.** Source identification and task matching pending.

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A.8 W8 - Welfare, medical and emergency facilities

Underground - Static workplaces

Table 47: W8 - Underground - Static workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Miners' boxes and waiting places			
MVSSA Data Book [10]	Waiting places and refuge bays	**20**; minimum; grid/ statistic unspecified	**Direct**
MT/T 1248:2025 [58]	Waiting rooms, refuge places, fire-material stores and explosive-storage rooms	**20**; table minimum; averaging unspecified	**Direct**
Area: Refuge bays and chambers			
MVSSA Data Book [10]	Waiting places and refuge bays	**20**; minimum; grid/ statistic unspecified	**Direct**
MT/T 1248:2025 [58]	Waiting rooms, refuge places, fire-material stores and explosive-storage rooms	**20**; table minimum; averaging unspecified	**Direct**

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Shared and supporting facilities - Common and supporting workplaces

Table 48: W8 - Shared and supporting facilities - Common and supporting workplaces.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Change houses and ablution facilities			
SANS 10114-1:2020 [11]	Cloakrooms, washrooms, bathrooms and toilets	**200**; maintained average	**Direct**
ISO/CIE 8995-1:2025 [23]	Cloakrooms, washrooms, dressing/locker/shower and toilet areas	**200**; conditional **300**; maintained average; source context modifiers apply	**Direct**
AS/NZS 1680.2.1:2008 [62]	Changing and locker rooms	**80**; maintained average	**Direct**
AS/NZS 1680.2.1:2008 [62]	Toilets	**80**; maintained average	**Direct**
Area: Fire-equipment and first-aid access points			
SANS 10114-2:2020 [43]	First-aid/fire equipment and call points away from routes/open areas	**5**; emergency floor-level minimum	**Direct**

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W8 - Shared and supporting facilities - Common and supporting workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: First-aid stations and medical-attention rooms			
MT/T is underground coal; DGMS is opencast metalliferous; compare within each stated setting.			
SANS 10114-1:2020 [11]	Sick bays; rooms for medical attention	**500**; maintained average	**Direct**
ISO/CIE 8995-1:2025 [23]	Sick bay	**500**; conditional **750**; maintained average; source context modifiers apply	**Direct**
ISO/CIE 8995-1:2025 [23]	Rooms for medical attention	**500**; conditional **1000**; maintained average; source context modifiers apply	**Direct**
AS/NZS 1680.2.1:2008 [62]	First-aid treatment rooms	**320**; maintained average	**Direct**
DGMS Circular 03/2017 [42]	First-aid station	**50 H**; source minimum; H horizontal / V vertical	**Direct**
MT/T 1248:2025 [58]	Health/medical room	**100**; table minimum; averaging unspecified	**Direct**
Area: Interior emergency assembly and open areas			
SANS 10114-2:2020 [43]	Emergency open-area / anti-panic lighting	**1**; emergency floor-level minimum	**Direct**
Area: Outdoor assembly points			
SANS 10389-1:2003 [12]	Walkways exclusively for pedestrians	**5**; minimum maintained average	**Direct** — Ordinary outdoor pedestrian access.
EN 12464-2:2024 [59]	Walkways exclusively for pedestrians	**5**; maintained average	**Direct** — Ordinary outdoor pedestrian access.
Area: Rest rooms and canteens			
SANS 10114-1:2020 [11]	Rest rooms	**100**; maintained average	**Direct**
ISO/CIE 8995-1:2025 [23]	Canteens and break areas	**200**; conditional **300**; maintained average; source context modifiers apply	**Direct**
ISO/CIE 8995-1:2025 [23]	Resting rooms	**200**; conditional **300**; maintained average; source context modifiers apply	**Direct**
AS/NZS 1680.2.1:2008 [62]	Rest rooms	**40**; maintained average	**Direct**
DGMS Circular 03/2017 [42]	Rest shelter	**30 H**; source minimum; H horizontal / V vertical	**Direct**

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W8 - Shared and supporting facilities - Common and supporting workplaces. (continued)

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
Area: Washroom mirror positions			
ISO/CIE 8995-1:2025 [23]	Facial lighting in front of mirrors	**200 V**; conditional **300**; maintained average; source context modifiers apply; 0.5 m in front of mirror at head height	**Direct**

Additional published reference criteria

Table 49: Additional source criteria used in the selected reference schedule.

Source	Published task and area	Recommended illuminance (lx)	Connection to mining application
SANS 10114-1:2020 [11]	Testing, measurement and inspection	500; maintained average; Actual defined task surface	Industrial inspection category; application to mining rock examination is a project task adaptation.
SIM 160701 final report [9]	Mobile equipment illumination in the direction of travel	10; all three readings at 20 m: table more than 10 lx; accompanying prose at least 10 lx; equipment lights only; Vertical detector facing equipment at three points 20 m ahead, 1 m above floor or operator attention height	Published directional equipment-output test. The selected acceptance rule and transverse sampling positions are in Appendix B.
SIM 160701 final report [9]	Potential personnel-machine and machine-machine interaction points around fixed equipment	50; at least three of five readings at every interaction point are at least 50 lx; At each interaction point, 1 m above floor; one horizontal and four vertical directions	Published fixed-equipment interaction test. Application as a mobile-interface task-surface minimum is a separate project adaptation.

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B BASIS FOR THE PROJECT RECOMMENDATIONS

B.1 Source facts and adopted applications

The 69 selections resolve the nine application groups previously held for appraisal. The published numerical baseline, task and source remain identifiable. A direct source use, a mining task analogy and an adopted measurement protocol are distinguished in the maintained register. These are selected guideline references; their inclusion does not claim an independently validated visibility threshold or establish legal applicability.

Relevant MVSSA, SANS and previous South African mining guidance are considered without a fixed ranking. Where an international provision supplies the closer task match, its mining application is stated. Competing values are not averaged and the highest value is not selected by default. Reproductions do not establish independent corroboration.

B.2 Assessment basis for the completed selections

Underground location minima. The MVSSA table publishes location minima but does not define a full assessment plane, grid or maintenance state. This guideline adopts in-service point minima at the actual access, floor, operating or interaction surfaces identified in each decision. Use fixed or portable workplace lighting for the location provision, with caplamps supplementary. Assess the full named area, including shadowed and adverse positions relevant to the task; use an area-specific set of representative and critical points rather than a universal mine-wide grid. Keep workshop background provision separate from local detailed work [10].

Dedicated route background. GAP 804 directly gives 5 lx minimum background for designated pedestrian and dedicated stope travelling routes, additional to caplamps. Its ground-horizontal, along-route method is adopted for these routes. The 20 lx references continue to apply where a route portion also belongs to a named haulage, crosscut, ladderway or inclined-shaft category [2].

Mining task adaptations. Coarse cleaning, face/drill positioning and ordinary support alignment use unchanged 200 lx task baselines; ordinary charging identification uses the 300 lx medium-assembly baseline. The three ISO assembly-based applications retain task minimum-to-average uniformity of at least 0.60. Systematic examination of visible rock features uses the SANS 500 lx testing/inspection class; difficult fine local inspection uses the 750 lx scribing/inspection class. These are explicit mining analogies, assessed over the defined local task area on the actual rock, mark, joint, contact or connector plane with usable combined task lighting. No automatic absent-daylight increment is applied [11, 23].

Equipment and cab decisions. For the travel test, the project chooses more than 10 lx to satisfy the stricter source-table wording, while retaining the neighbouring meet-or-exceed wording in the source record. Left, centre and right positions across the machine envelope are the project's transverse sampling convention. The direct fixed-equipment criterion remains a three-of-five directional test. The 50 lx mobile-interaction surface minimum is a declared project adaptation, with the actual interaction surface and normal machine position specified. Cab local-task provision uses a stationary 50 lx horizontal adaptation of

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the published opencast cab value; the original cab source does not itself state a stationary exemption. During travel, self-lit readable instruments, adjustable brightness and an unobstructed exterior view govern the display arrangement [9, 42].

Emergency and refuge operation. The emergency references retain the source floor geometry, response times, uniformity and duration. An escape route up to 2 m wide uses its horizontal floor centreline; wider routes use 2 m strips or the open-area method. Open-area assessment includes the empty floor area and retains the source's provision for assessment up to 0.5 m on the perimeter; no perimeter exclusion is introduced. The high-risk criterion is the greater of 20 lx and 10% of normal task illuminance, on the source's average horizontal basis; its task-to-surrounding-point ratio at 5 m is no more than 10:1. Underground emergency systems provide at least 3 h, or the longer applicable risk period. Sustaining the normal refuge minimum of 20 lx throughout occupied emergency use is a project service-state adaptation; it does not substitute the escape-lighting duration for the refuge's designed occupancy period [43, 10].

B.3 Completed coverage decisions

The following records replace the former unresolved list. Earlier decision states remain preserved in the dated pre-revision snapshot.

X01 – Underground haulages, access crosscuts and shaft approaches
Select the named MVSSA location minima and the separate GAP804 dedicated-route background minima. Preserve the distinct 20 lx general-location and 5 lx dedicated-walkway categories. Project-defined in-service point minima at actual access/floor/operating surfaces with fixed or portable workplace lighting; caplamps supplementary and excluded from the baseline.

X02 – Mobile-machine travel, working task and person interaction
Select the conservative $>$10 lx travel-direction equipment test separately from the explicitly adapted 50 lx mobile work/person-interaction surface minimum. Travel detector geometry and equipment-only state are separate from actual working/person targets and their credited combined task lighting. Higher detailed-task references remain applicable.

X03 – Extraction, development, rock examination and support tasks
Select six explicit mining-task adaptations of industrial visual-task categories plus the direct continuous-miner interface minimum; retain each published numerical baseline. Actual rock/mark/contact/joint/connector/inspection planes and operating postures, with recorded usable fixed, portable and personal task lighting; no universal workface plane.

X04 – Underground ore loading, crushing and conveyor interaction
Select the named underground MVSSA location minima and the direct SIM fixed-equipment interaction test separately. Location point minima do not replace the fixed-equipment five-direction test or the higher reference for a detailed task.

X05 – Underground general workshop provision
Select the distinct 400 lx major-maintenance and 200 lx service-only underground workshop location minima. Normal workshop background/location provision with caplamps excluded from its measurement; separate local task references apply to maintenance and inspection work.

X06 – Underground pumps, substations, fan and battery rooms
Select the named 100 lx underground utility-room/battery-bay location minima, with the

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fan category limited to permanent chambers above 50 kW. Project-defined in-service point minima for the relevant operating surfaces; detailed labels, inspection or repair tasks receive separate task lighting.

X07 – Mobile cab instruments, controls and outside view
Select 50 H as an explicit project adaptation for stationary local cab tasks. Travelling instruments and the exterior view use performance criteria and the separate exterior lighting references. No 50 lx whole-cab ambient requirement during night travel. Self-lit readable instruments and adjustable brightness preserve external target visibility and control windscreen reflections.

X08 – Underground waiting places and refuge bays
Select the MVSSA 20 lx normal-use waiting/refuge location minimum. For an occupied refuge, explicitly extend 20 lx under emergency supply throughout its designed occupied emergency period; retain separate escape/open-area/equipment emergency references. Normal and failed-supply states are separate. Occupied refuges maintain the project-adopted 20 lx for the full designed occupied emergency period, which may exceed 3 h. Normal waiting-place escape lighting uses the separate source plane, activation and duration criteria; underground emergency duration is at least 3 h.

X09 – Emergency escape, open-area and hazardous-task lighting
Complete dedicated emergency appraisal and select escape-route, open-area, equipment-access and high-risk-task references. Keep minimum versus average, actual emergency plane, failed-normal-supply state, activation, end-of-life output and full rated duration explicit; apply surface and underground duration requirements separately.

B.4 Source development and revision

These numerical baselines are published recommendations. Their repetition in several documents does not validate a common threshold. The MVSSA table attributes its underground values to departmental recommendations; SIM 160701 describes best-practice and workshop input. Source facts and project applications remain separate so that a changed task, source interpretation or new evidence can support a documented revision [10, 9].

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C SUPPORTING ASSESSMENT METHODS AND RECORDS

Use this material when the assessment question calls for detailed measurements. Section 9 explains the choice of method and its limits. The procedures below retain the selected source's conditions; they do not validate the numerical target or impose one universal survey design on every mine.

C.1 Planning the Measurement

Before undertaking a lighting survey, define its purpose, the area to be assessed, the visual tasks performed, and the applicable lighting requirements. For routine surveys, measure illuminance on the relevant task or travel surfaces. Identify any need for specialist luminance or surface-reflectance assessment separately, including the relevant observer positions. A measurement plan should include the following information:

- The workplace layout, dimensions, machinery, fixed obstructions and the locations of visual tasks.
- The lighting arrangement, including luminaire types, locations, mounting heights and operating modes.
- The reference planes, measurement heights, measurement points and measurement grid, where applicable.
- The condition of lamps and luminaires, including visible dirt, damage and maintenance history where available.
- Relevant operating and environmental conditions, including ambient temperature, supply voltage and any daylight contribution.

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Prepare a numbered sketch or plan of the measurement locations. For routine repeat surveys, use identifiable reference points to facilitate comparison of results.

Lighting performance is generally evaluated in terms of average illuminance, illuminance variation (illuminance uniformity or diversity), glare limitation (maximum luminance, Unified Glare Rating (UGR) for interior lighting, or Glare Rating (GR) for exterior lighting), and colour rendering index (CRI). Average illuminance, illuminance uniformity, illuminance diversity, and surface luminance can be determined through field measurements. UGR and GR shall be calculated for specified viewing positions and directions, while CRI is a characteristic of the light source.

C.2 Measuring Instruments

Use a suitable calibrated illuminance (lux) meter for the field surveys described in this guide. Where glare or reflection problems require luminance or surface-reflectance measurements, refer them for a separate specialist assessment.

Illuminance meters should have a spectral response approximating the photopic luminous-efficiency function $V(\lambda)$ and appropriate cosine correction for plane illuminance measurements. In each case, ensure that the meter has an error tolerance not exceeding 10 %. [43, 64, 26, 3].

Before the survey:

- Check the calibration status, condition, battery and measuring range of each instrument; record its identification and relevant accuracy or uncertainty information.
- Keep the detector clean and position it according to the instrument manufacturer's instructions.
- Allow the lighting installation and measuring instruments to reach stable operating conditions before recording readings; confirm stability by repeated readings where necessary.
- Record the lighting control state (for example, switching or dimming level) and, where relevant, the electrical supply and ambient conditions.
- Use only measuring equipment authorised for the applicable hazardous area where explosive atmospheres may occur.

For existing installations, carry out measurements under the operating conditions being assessed, without adjusting readings to conceal deterioration caused by ageing or dirt. Where measurement results are compared with a design prediction, record any differences between the installed system and the design conditions [26].

C.3 Selection of Measurement Planes and Points

C.3.1 Measurement planes

Position the illuminance meter sensor in the plane relevant to the visual task. Measure horizontal illuminance on horizontal task or travel surfaces, vertical illuminance on vertical surfaces, and illuminance on inclined planes where tasks are performed on such surfaces. Record the position, height and orientation of each reference plane [26].

For traffic and haulage ways, the original mine-lighting measurement procedure specifies measurements within $0.2\,\mathrm{m}$ of the floor. At individual working positions, measure at the normal task height. At mining faces, use representative measurement positions on the face; the original procedure includes measurements near floor level, at an intermediate position and near roof level. These are conditions of that particular procedure. Check their compatibility with the selected criterion before using them; another reference may define a different assessment plane or height.

C.3.2 Sampling required by the selected method

First distinguish room or general-area verification from a specific task, route section or equipment test. Use the surface, point locations, extent, repeats and statistic required by the matching criterion and measurement method. The practical selection is explained in Section 9; this appendix does not prescribe a grid survey of the mine's tunnel network and work sites.

Where the method selected for a defined room or bounded area calls for a regular grid, follow that method's full provisions. For the SLL procedure retained here, approximately square cells have a length-to-width ratio between 0.5 and 2, with readings at their centres. Its maximum-spacing relationship is [26]:

$$p = 0.2 \times 5^{\log_{10} d}, \tag{3}$$

where p is the maximum grid spacing (m) and d is the specified reference dimension of the measurement area (m). For outdoor workplaces, the grid-spacing provisions also limit p to

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$10\,\mathrm{m}$; where the ratio of the longer to the shorter dimension is at least two, use the shorter dimension for d [26]. Divide each dimension by a whole number of cells so that the final spacing does not exceed p. Locate the first measurement point half a cell spacing from the boundary.

Apply this relationship only within the scope of the selected bounded-area method; it is not a spacing rule for all mine routes or work sites. For task, route or equipment assessments, establish the locations and surfaces required by the applicable reference and document them. Retain critical poorly illuminated positions and task locations near walls or obstructions where relevant to that assessment.

C.4 Measurement Procedures

C.4.1 Illuminance measurement

At each specified point, place the sensing surface at the required height and orientation. Avoid introducing shadows or reflections from the person taking the measurement, except where worker shadowing is part of the task condition being evaluated. Record all readings against the numbered measurement points [26, 3].

Measure the lighting in the operating state corresponding to the intended assessment. Include general and local lighting together when assessing the lighting available during normal work. To assess the contribution of an individual lighting system, measure with the other contributing systems controlled or excluded, where safe and practicable, and record the conditions.

Where the selected criterion requires a local minimum or task-area uniformity, obtain the spatial coverage required for that defined task and its surroundings. Identify supplementary investigation points separately; include them in an area average only where the adopted sampling and weighting method supports doing so [3].

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C.4.2 Specialist luminance assessment

The luminance and surface-reflectance methods below support a separately scoped specialist investigation; they are not routine lux-survey requirements.

Measure luminance from representative worker eye positions and viewing directions. Aim the meter at the task, surrounding surfaces or the suspected bright source. Ensure that the target fills the instrument's measurement field, and record the viewing position and direction [3]. Where glare indices such as UGR or GR are required, evaluate them using the applicable calculation method rather than treating an illuminance reading as a direct glare measurement [26].

C.4.3 Specialist surface reflectance assessment

For approximately diffuse surfaces, measure the luminance of the test surface and of a calibrated diffuse reflectance standard placed in the same position and orientation under the same illumination. Keep the luminance meter at the same viewing position for both readings. Calculate the surface reflectance as [3]:

$$\rho_{\mathrm{sur}} = \rho_{\mathrm{std}} \frac{L_{\mathrm{sur}}}{L_{\mathrm{std}}}, \tag{4}$$

where ρ_{std} is the reflectance of the standard and L_{sur} and L_{std} are the measured luminances. For an approximately Lambertian surface, reflectance may alternatively be estimated as

$\rho \approx \pi L/E$, where E is the illuminance at the surface and L its luminance. Do not use this approximation for highly specular surfaces.

C.5 Calculating and comparing measurement results

For n illuminance readings representing equal-area cells, calculate the average illuminance as:

$$E_{\text{avg}} = \frac{1}{n} \sum_{i=1}^{n} E_i. \tag{5}$$

If the readings represent unequal areas, calculate an area-weighted average where appropriate:

$$E_{\text{avg}} = \frac{\sum_{i=1}^{n} A_i E_i}{\sum_{i=1}^{n} A_i}, \tag{6}$$

where A_i is the area represented by measurement i. Calculate the overall uniformity and, where relevant, the minimum-to-maximum ratio as:

$$U_0 = \frac{E_{\text{min}}}{E_{\text{avg}}}, \qquad U_d = \frac{E_{\text{min}}}{E_{\text{max}}}. \tag{7}$$

Compare the results with the applicable requirements for the same task area, reference plane and operating conditions. Check average illuminance and uniformity separately. Where a result is close to a specified limit, consider the stated instrument accuracy and relevant measurement uncertainty before recording a verification conclusion [26, 3].

Where a measured result does not meet the applicable requirement, record the location and value of the deficiency and refer it for corrective action. Repeat the affected measurements after corrective work, using comparable measurement locations and operating conditions.

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C.6 Measurement Records and Reporting

Keep a record containing the following information [26, 3]:

1. Mine, workplace, visual task, measurement purpose, survey date and personnel.
2. Lighting-system description, luminaire arrangement and relevant maintenance condition.
3. Measurement instruments, identification numbers, calibration status and relevant accuracy information.
4. Reference surfaces, measurement heights, orientations and a numbered plan of measurement points.
5. Operating conditions, including lighting-control state, relevant ambient conditions and other contributing light sources.
6. Individual measured values, calculated averages and uniformity results, and the applicable requirements.
7. Any correction applied to the readings, together with its basis, and any limitations affecting the assessment.

8. Verification results, identified deficiencies, corrective actions and remeasurement results, where applicable.

Present illuminance readings in a table or on the measurement plan. Where useful, include an illuminance contour plot or annotated photographs to show the distribution of light over the assessed area.

C.7 Worked interpretation example

The following readings are invented solely to explain calculation and interpretation. Four equal-area cells on a defined task plane give 180, 220, 200 and 200 lx with the documented combination of lights. Their average is 200 lx, the observed minimum is 180 lx and the minimum-to-average ratio is 0.90.

These results describe the sampled plane and state. A 200 lx maintained-average reference would require a different interpretation from a 200 lx point-minimum reference: the same set can meet the numerical average comparison while containing a sampled point below 200 lx. The example does not select either reference for a mine task, establish the unsampled minimum, or demonstrate maintained performance from one survey.

Suppose a reflection still hides the gauge marking. The appropriate response is to investigate the source–surface–eye relationship, record the change and recheck the task; the average reading alone does not resolve that problem.

C.8 Reusable assessment and improvement record

Table 50: Blank assessment record. Complete the fields for the actual task; blank means not recorded, not not-applicable.

Field	Record
Mine, workplace and date	
Activity and critical information	
Worker viewpoint and operating state	
Purpose of assessment	
Selected reference, source and status	
Task surface, extent and numbered points	

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Field	Record
Instrument, calibration and limitations	
Credited light sources and conditions	
Raw readings and calculation attachment	
Glare, shadows, reflections and sightlines	
Result and what remains unverified	
Corrective action and responsible role	
Recheck conditions, date and result	
Further investigation / review trigger	

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For the illustrative case above, the record would identify an invented four-cell survey, attach the four values and calculation, and record the obscured gauge marking separately. It would state that numerical comparison depends on the selected statistic, refer the reflection for an arrangement change, and require a comparable recheck. Responsibility and operational authorisation belong to the mine's established arrangements; this blank form does not assign them.

C.9 Supporting calculations for lighting design

This subsection supports the output-selection method in Section 5.5. It distinguishes a preliminary average estimate, calculations at particular points and a luminance-based design. All numerical examples use invented inputs to teach the arithmetic; they are not measured installations, product recommendations or additional mining limits.

Obtain utilisation data for the proposed room and fitting. For a regular interior, first define the assessment plane and the room dimensions. The room index used with a

matching utilisation table is

$$K = \frac{\ell w}{h_m(\ell + w)}, \tag{8}$$

where ℓ and w are room length and width and h_m is the vertical distance from the luminaire's photometric centre to the assessment plane, all in metres. Mounting height above the floor is not h_m when the task plane is above the floor. Use the manufacturer's method where the geometry or table convention differs [26].

Select the table for the exact luminaire and optic, then the entries matching the room index and the ceiling, wall and floor-cavity reflectances. Follow the supplied interpolation and applicability instructions. The floor cavity includes the space below the reference plane. An assumed bright ceiling can overstate the reflected contribution in a dark excavation. A room table does not represent a machine blocking the beam, a narrow recess or an upright gauge [26, 3].

Check the flux convention before using Equation 1. The SLL Code's lamp-based expression uses initial bare-lamp lumens, lamps per fitting and a lamp-based utilisation factor. Here the total is expressed in *complete-fitting lumens*, so obtain a utilisation factor on that basis or use the supplier's original lamp-based calculation consistently. Do not multiply an LED fitting's declared output by a bare-lamp factor or deduct internal optical losses already included in that output. If matching data are unavailable, obtain a photometric layout calculation rather than inventing a factor [26].

Choose a quantity, then calculate the actual layout. Divide the estimated total initial lumens by the initial output of one candidate complete fitting. Round the number upwards to a feasible arrangement and recalculate its maintained average. If changing the product, optic, mounting height or layout changes the utilisation factor, repeat the estimate with the matching data. Use the proposed spacing and edge coverage in the layout check; the lumen total alone cannot establish uniformity [26].

For arithmetic only, suppose the maintained average is 200 lx over 50 m^2, with hypothetical $UF = 0.50$ on a complete-fitting basis and $MF = 0.80$. Equation 1 gives $200(50)/(0.50 \times 0.80) = 25\,000$ initial lumens. Four hypothetical 6500 lm fittings supply 26 000 lm and would give $26\,000(0.50)(0.80)/50 = 208$ lx maintained average *if the assumed factors apply to that arrangement*. This is not a verified design: its minima, glare and task visibility remain to be calculated or assessed. Neither the factors nor the task value are mine defaults.

Use manufacturer tables or files to predict light on the actual surfaces. A lux table may give illuminance at stated distances or mounting heights. Check whether its values describe the beam centre, a minimum, an average or another result, and identify the receiving-plane orientation and output setting. A centre-beam reading does not establish coverage of a whole task. An isolux diagram joins points of equal illuminance; its distances, plane, aiming and lumen basis must match the proposed use. A quoted beam angle alone does not mean that light is uniform within that angle or absent outside it [26, 13].

An IES or LDT file supplies photometric distribution data for a lighting calculation [65]. Use the exact product variant, optic and operating setting, with its stated absolute or normalised output convention. Model the mounting positions, orientation, relevant planes, major obstructions and realistic surface reflectances. Obtain the predicted average, minima and uniformity on each required surface, with the maintenance basis stated. Evaluate glare

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and the worker's view as well as the numerical distribution. Compare alternatives in the model before purchase, then verify the as-built installation [26, 16, 14].

Scale lumens only while distribution and geometry remain unchanged. For the same optical distribution and unchanged geometry, illuminance scales with lumen output. If a manufacturer table or model gives an initial illuminance $E_{\mathrm{ref,initial}}$ for output Φ_{ref}, the initial output needed for a maintained target is

$$\Phi_{\mathrm{required,initial}} = \Phi_{\mathrm{ref}} \frac{E_{\mathrm{required,maintained}}}{MF\, E_{\mathrm{ref,initial}}}. \tag{9}$$

Use the same point or area statistic, receiving plane and lighting state in both illuminance values. The relationship follows from the linear contribution of the supplied photometry; it applies to one specified fitting or a fixed layout whose outputs all scale alike. Other unchanged lighting contributions must be treated separately. If the reference prediction already includes the same maintenance allowance, compare maintained values directly rather than applying MF again [26].

Confirm that an available lumen package actually retains that distribution and output basis. A higher-output product may have a different optic or emitting area; dimming may change operating characteristics. Recalculate changed positions, aiming, optics or obstructions. Uniform scaling multiplies the minimum and average by the same factor, leaving their ratio unchanged; it cannot fill a dark gap relative to the rest of the area. Nor does it establish acceptable glare.

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Use the appropriate source model for a point calculation. For an unobstructed point-source approximation, direct illuminance at one point is

$$E = \frac{I_\gamma \cos\theta}{r^2}, \tag{10}$$

where E is in lux, I_γ is luminous intensity in candelas *towards that point*, r is source-to-point distance in metres, and θ is the angle between incoming light and the normal to the task surface. The normal is perpendicular to that surface. Candela describes the directional photometry used in this calculation; it is distinct from the fitting's total lumen rating [26].

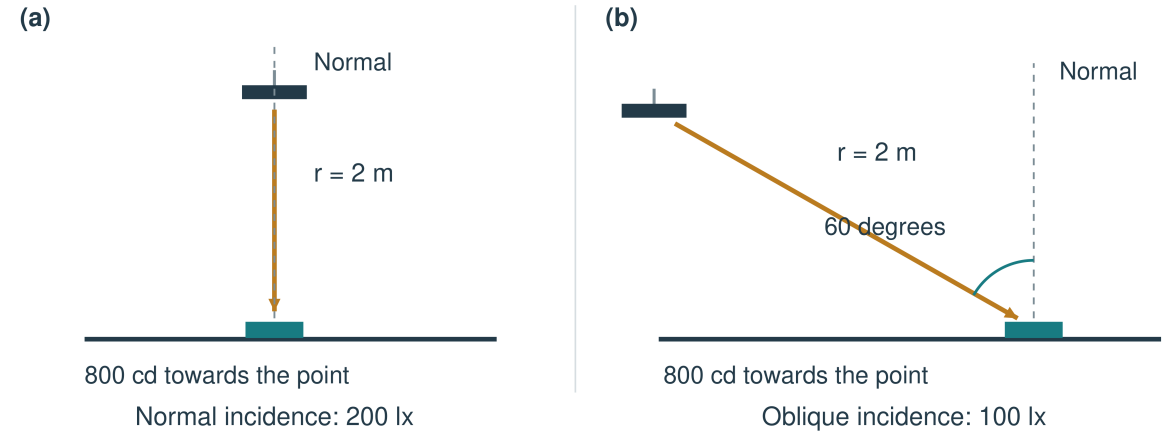


Figure 32: Distance, intensity towards the target and incidence angle determine a direct contribution. The normal belongs to the task surface and is not necessarily vertical. The sketch illustrates Equation 10, without reflected light or obstruction.

The SLL Code describes the usual point-source approximation where the distance is at least five times the largest source dimension. Use a suitable extended-source or near-field model where that approximation is not justified. A long strip close to a task cannot automatically be treated as one point. The equation estimates one direct contribution, excluding reflected light and obstruction [26].

Find intensity towards the point from the correctly oriented photometric data. Some diagrams are normalised in cd per 1000 lm: scale them by the specified flux in thousands of lumens on the stated lamp or luminaire basis. Do not scale absolute candela data a second time. The fitting's aiming angle is not necessarily the incidence angle to the assessed surface normal.

Worked example: distance and direction. Suppose a fitting supplies 800 cd towards a point 2 m away at normal incidence. Its direct contribution is $800/2^2 = 200$ lx. At the same distance and directional intensity, 60° incidence gives $800\cos 60^\circ/2^2 = 100$ lx. At 4 m and normal incidence it gives $800/4^2 = 50$ lx. Re-aiming a real fitting changes which part of its intensity distribution reaches the target, so the 800 cd cannot simply be retained. Read the new directional intensity as well as angle and distance.

Add the contributions that reach the same point. Illuminance contributions from separate sources add on the same receiving plane under the same conditions. For point sources with unobstructed direct paths,

$$E_{\text{direct}} = \sum_{j=1}^{n} \frac{I_{\gamma,j}\cos\theta_j}{r_j^2}. \tag{11}$$

Include only sources incident on the assessed side of the surface. If an opaque obstruction completely blocks one path, that source contributes no direct illuminance at the point. Partial shielding, extended sources and reflected light require a model appropriate to their geometry. Add each contribution once; a full-light model must not be combined with its own separately counted components [26, 27].

For illustration, one source gives $800/2^2 = 200$ lx at normal incidence. A second supplies 600 cd at 3 m and 60° incidence, adding $600(0.5)/3^2 = 33.3$ lx. The direct sum is approximately 233 lx. If the second path is completely blocked, the sum returns to 200 lx. These values do not include reflected light, depreciation or other points in the workplace. The second fitting doubles the first contribution only if it too delivers 200 lx at that point; identical catalogue lumens alone do not establish this.

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Keep luminance requirements distinct from lux requirements. If the criterion is specified in cd/m^2, identify the surface and viewing direction as well as the required luminance. There is no direct unit conversion to lux or source lumens. For an approximately diffuse reflecting surface, the SI relationship is

$$L \approx \frac{\rho E}{\pi}, \qquad E \approx \frac{\pi L}{\rho}, \tag{12}$$

where L is reflected luminance in cd/m^2, E is illuminance on the surface in lux and ρ is its diffuse reflectance as a fraction. This approximation supplies a conditional illuminance target; the subsequent output calculation still needs geometry, distribution and any applicable maintenance allowance. Use representative reflectance evidence. Wet, polished or strongly directional surfaces need a reflection model and viewing geometry appropriate to them; this diffuse relationship also does not describe a self-luminous display [13, 3].

Interpret maintained values and area statistics consistently. For a maintained illuminance criterion, $E_{\text{initial}} = E_{\text{maintained}}/MF$. Illustratively, 200 lx maintained with an assumed $MF = 0.80$ requires 250 lx initially. If the justified factor were 0.70, the initial value would be about 286 lx. This comparison shows sensitivity to the assumption; it does not justify choosing the more convenient factor. Preserve the selected reference's statistical basis and document the achievable maintenance programme [23].

The five values in Table 6 each represent the same area, so their arithmetic mean is appropriate for that illustration. Unequal represented areas require appropriate weighting; isolated supplementary readings used to locate a dark patch must not be silently added to a regular-grid mean. Follow the selected assessment method. A correct average estimate does not establish an adequate minimum, upright-task illumination or freedom from glare. Include sensitivity comparisons for material uncertain inputs, then verify the installed arrangement under the specified conditions [16, 14].

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D GLARE-CONTROL EXAMPLES AND LUMINAIRE CHOICES

The examples support Section 5.7. Installed changes, reported observations, simulations and component illustrations have separate labels. Photographic appearance alone is not a glare measurement. Source credits and unresolved publication-permission status are retained in the accompanying evidence and image records.

D.1 Aim light at the loading area

Published before-and-after installation

BEFORE **AFTER**

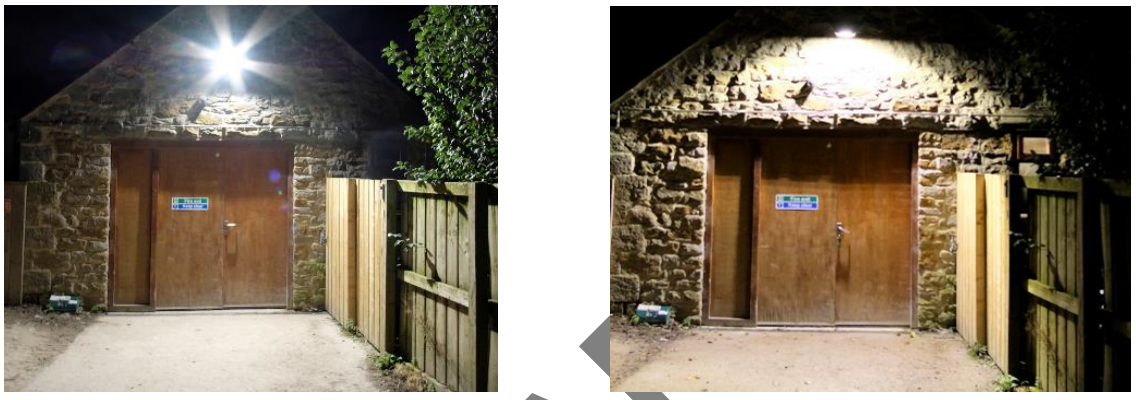


Figure 33: Loading-door lighting before and after an improvement reported by NYMNPA. Photographs: North York Moors National Park Authority. [28]

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The problem. The earlier fitting is a conspicuous exposed source above the doorway.
What changed. The authority describes replacing floodlights or aiming them down in this loading example. It reports sufficient operational light with reduced glare and spill. [28]
The useful view. Light remains on the doorway and ground while the source is less prominent from the photographed approach.
What to retain. Verify the actual loading, walking and approaching-driver views. Downward aiming must still reveal required upright targets and edges. [12, 14]
The views and exposures are not matched. The photographs support the documented intervention, not a numerical glare-reduction claim.

D.2 Reveal the path, rather than the lamp

Published installation retrofit / walking route

BEFORE (LEFT) / AFTER (RIGHT), AS PUBLISHED

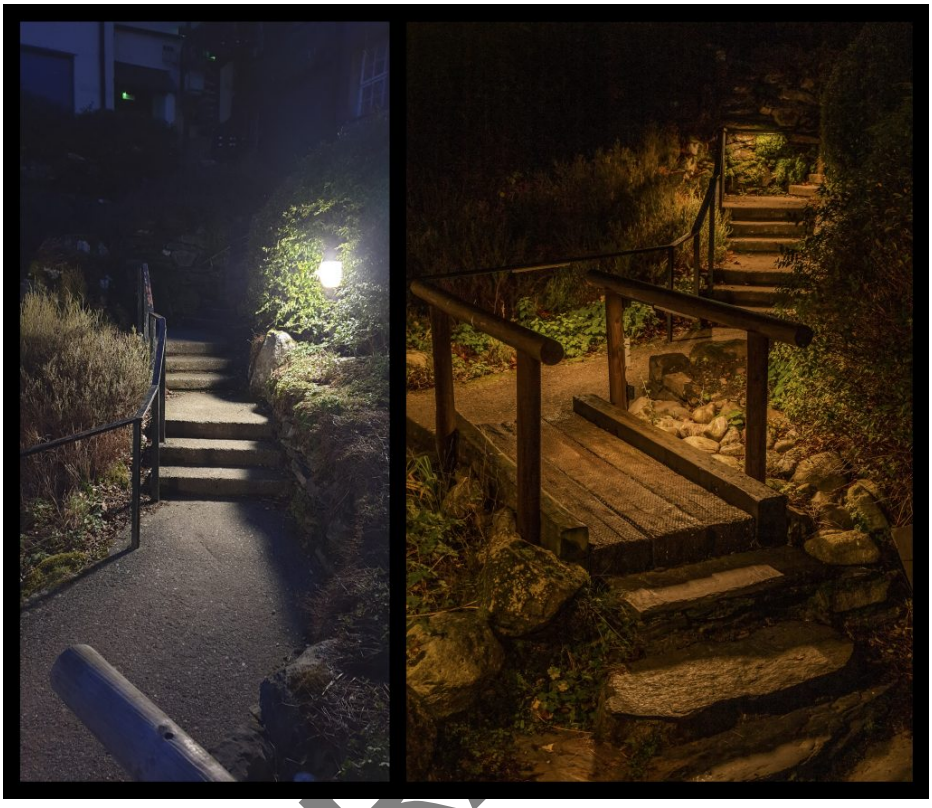


Figure 34: Steps and a footbridge at Plas y Brenin, National Outdoor Centre, Capel Curig. Published comparison: DarkSky UK / Prosiect Nos project, managed by Dani Robertson. Individual photographer not specified. [66]

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Difficulty. The project account describes harsh lighting alongside complaints that people still could not see or navigate safely. [66]
Change. The site's lighting was retrofitted. The source does not identify the fittings, shields or aiming changes for this particular pair. [66]
View and trade-off. The later photograph presents the steps and handrail with less conspicuous bright light in the view. This is an illustrative reading of the photographs, not a measured glare result. For a mine route, retain visibility of step edges, obstacles and approaching people. [15, 12]
Viewpoint and exposure are not controlled. Do not infer a required lamp colour, output or mine-route illuminance from these pictures.

D.3 Shielding and output must work together

Published park retrofit / contextual before and after

BEFORE: VISITOR-CENTRE WALKWAY



AFTER: LOWER-OUTPUT RETROFIT

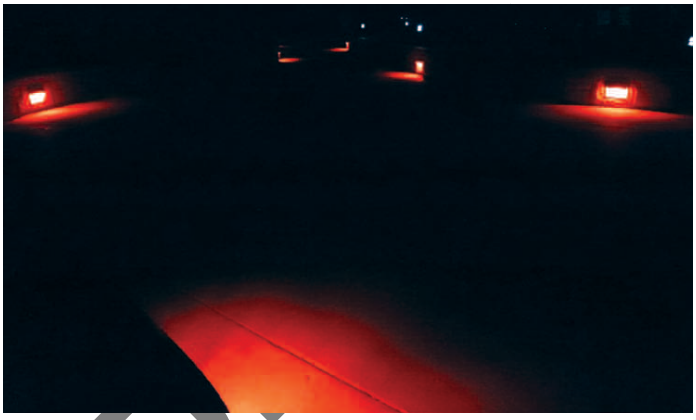


Figure 35: Bryce Canyon Visitor's Center walkway, as published by the International Dark-Sky Association. Complete original photographs; no exposure adjustments. [67]

What changed. The account describes excessive output despite many existing fittings being shielded. The visitor-centre retrofit replaced metal-halide lamps with much lower-output amber LEDs. [67]
Visual lesson. A shield alone cannot correct excessive illumination and reflected brightness. Set output for the actual task, then keep the emitting face and troublesome reflections out of required views. [15, 12, 14]
Trade-off. The park's astronomy setting differs from mining work. The dark after-image does not establish adequate recognition of obstacles, people or colour-coded information. Check those needs before lowering output. [15, 12]
Published installation change, not a measured human-glare or mine-task comparison. Colour, exposure and output changed together; no single cause is isolated.

D.4 See the retrofit inside the fitting

Same park project / component and doorway comparisons

BOLLARD BEFORE



BOLLARD AFTER



WALL LIGHT BEFORE



WALL LIGHT AFTER

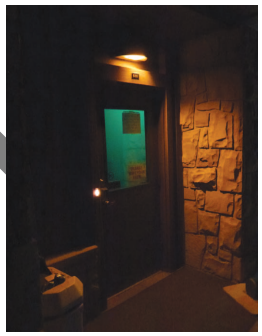


Figure 36: Bryce Canyon bollard and wallpack before/after photographs. Credit: International Dark-Sky Association; individual photographer unspecified [67].

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Change. The bollard images show the changed lamp assembly; the doorway pair shows another part of the same lower-output retrofit. [67]

Apply the lesson. Choose a compatible complete fitting or approved retrofit that controls light towards occupied eyes. A clear outer cover is not an opaque shield. Confirm where the source remains visible from standing, seated and approaching positions. [15, 14, 26]

Trade-off. Reduced output and shielding can reduce useful light on faces, signs and ground hazards. Retain enough illumination for those tasks; the park's amber appearance is not a mining prescription. [15, 12]

The source documents the retrofit, but these photographs do not isolate the effect of each optical component or measure glare.

D.5 Control the fitting and light the surroundings

Published before-and-after renovation

BEFORE RENOVATION **AFTER RENOVATION**



Figure 37: A residential corridor before and after lighting renovation. The published account identifies a fitting with cross-baffles and redirected light towards the walls. Images: Lighting Research Center DELTA Program; courtesy of copyright Randall Perry Photography, LLC, via IES. [31]

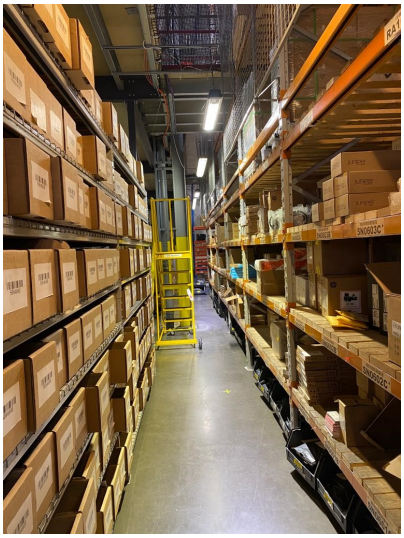
The problem. The source account describes an excessively bright luminaire and its reflection in a shiny floor.
What changed. Cross-baffles limit the direct view of the source while the new distribution illuminates the walls. [31]
The useful view. The lesson combines source control with surrounding illumination; it is not simply a reduction in the amount of light everywhere.
What to retain. For a mine building, preserve route and obstacle visibility and check other eye heights. Indoors, clean matte surfaces can support useful interreflection. [11, 3]
This is a building example, not a mine trial. Photographs are reproduced from a scanned textbook; exposure and other renovation changes were not independently controlled.

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D.6 Match the fitting to the working aisle

Supplier case account / installed before and after

BEFORE, AS LABELLED BY SUPPLIER



AFTER, AS LABELLED BY SUPPLIER

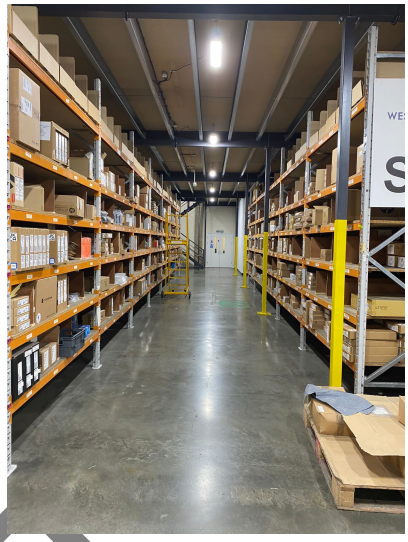


Figure 38: Westcoast Ltd warehouse comparison, published by LED by Vision. Different camera framing; complete original image files. [68]

Difficulty and change. The supplier describes poor illumination in pick/pack lanes and a separate quality-control area. Reduced glare is reported for the quality-control area. The aisle photographs and customer account illustrate changed coverage with fewer fittings, without an independent aisle-glare measurement. [68]

Visual lesson. Select output, optics and spacing for the aisle and task. More lower-output fittings is one remedy; the useful result depends on distribution and positions rather than lamp count alone. [15, 29, 14]

Trade-off. Maintain vertical visibility on stored items and labels as well as light on the floor. This account does not establish which particular optic caused the reported benefit. [15, 68]

Supplier/customer observations, not independent glare testing. Do not transfer the separate quality-control lux target to this aisle or to mine work.

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D.7 Avoid these exposed-source arrangements

Selection comparison / components, not tested installations

AVOID: OPEN TUBES IN REQUIRED VIEWS **CONSIDER: COMPATIBLE OPTICAL COVER**





Bare fluorescent batten: choose an enclosed, optically controlled fitting for occupied views. A prismatic cover changes brightness and distribution; confirm its actual effect. [17, 69]

AVOID: BRIGHT EXPOSED UFO FACE **CONSIDER: SUITABLE OPAQUE SHIELD**





Round pancake/high-bay: conceal the bright face with suitable depth, shielding and placement. The illustrated products are from different families, not an approved retrofit pair. [15, 70, 71]

AVOID: FLOODLIGHT FACING PEOPLE **CONSIDER: AIMING AND OPTICAL SHIELD**





Wall or pole floodlight: avoid directing the emitting face at routes or operators. Choose controlled optics, appropriate output and a compatible hood where needed. [12, 72]

Figure 39: Component illustrations: Ansell Lighting; NICOR Lighting; ABOVE ALL Lighting. Not matched before/after installations or a verdict on every product of these shapes. [70, 72, 71, 69]

Compact LED arrays can have very bright points and strong luminance contrasts. CIE reports that average-source UGR can underestimate discomfort for such non-uniform sources. [73] Select the complete fitting and view; technology or shape alone does not establish installed glare.

DRAFT

D.8 Use depth to screen the source

Luminaire catalogue / recessed reflector and baffle principle

RECESSED DARKLIGHT REFLECTOR **RECESSED FITTING AND TRIM**





Figure 40: WE-EF DOC-family manufacturer illustrations. The deep reflector and recessed aperture make the source less exposed from some directions. Product-photo/rendering origin not established. [74]

Mechanism. Recess the bright parts behind the aperture; add a suitable baffle to block troublesome lines of sight. Reflectors also direct useful light. The HSE fitting catalogue and SLL Code distinguish these forms of control. [17, 26]
Choose and position. Check the view from actual work and approach positions, including upward looks. A reflective surface can itself look bright, and a ceiling recess does not conceal the source from every direction. [15, 26, 75]
Trade-off. Deeper shielding can reduce sideways illumination. Choose spacing and distribution that still reveal faces, vertical tasks and obstructions; add appropriately placed lighting where needed. [15, 17]
Illustrative architectural products. Their optical principles do not establish suitability or approval for a particular mining environment. No catalogue shielding angle is adopted.

DRAFT

D.9 A louvre screens; a lens redirects

Luminaire catalogue / cellular shield and optical accessories

HONEYCOMB LOUVRE



LINEAR SPREAD LENS



FLOOD LENS



WALLWASH LENS



Figure 41: Separate WE-EF internal optical accessories, as identified on the source page. Factory installation and model compatibility apply. These are component illustrations. [74]

Cellular shielding. The opaque cells obstruct selected oblique lines of sight to the source. Choose their orientation and depth for the occupied view; light still exits through the openings. [15, 17, 26]
Lenses and light guides. A refracting lens changes the distribution; it need not hide the emitter. A true light guide transports light within a material before it is emitted elsewhere. Do not call every louvre, reflector or lens a light guide. [75]
Trade-off. Screening and optical losses may reduce useful illumination; dust on cells or lenses changes performance. Select a compatible complete assembly and maintain it. This family permits only one specified internal accessory at a time. [15, 14, 74]
A screen and a spread lens solve different problems. An accessory photo or a generic 'low glare' label does not show its performance at the worker's eye.

DRAFT

D.10 Recognise the exposed round high-bay

Fitting and component illustrations

EXPOSED UNDERSIDE



OPAQUE REFLECTOR



TRANSPARENT CONICAL SHIELD



DROP SHIELD ASSEMBLY



Figure 42: Round UFO/high-bay forms and optical accessories. Left: NICOR HBC5 product image. Other assemblies: ABOVE ALL Lighting. These are different product examples, not a tested before-and-after installation. [70, 71]

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The glare risk. A flat round fitting can leave its emitting aperture visible from below and from some inclined views. Whether it causes glare depends on its luminance, distribution, location and the worker's view. [15, 23]

Useful controls. An appropriate deep opaque reflector or recess can screen some views. A transmitting accessory changes the visible surface and distribution; its name alone does not establish how well it conceals the source. [15, 70, 71]

What to retain. Select the complete fitting and optical assembly using relevant photometry. A rim that screens a horizontal view may leave a worker looking up directly at the aperture. [15, 23]

Unlit manufacturer product images identify components. They do not show installed glare, establish poor quality or imply approval for mining use. Image photographic/rendered origin is unverified.

D.11 Spread brightness across a controlled surface

Luminaire catalogue / diffuser and prismatic surfaces

LED BOARD AND DETACHED OPTICAL COVER **ENCLOSING PRISMATIC BATTEN COVER**

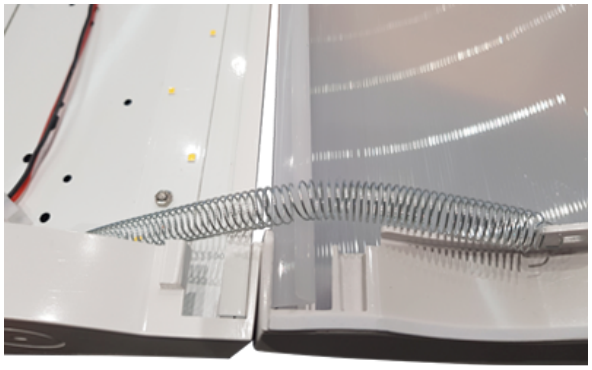




Figure 43: Left: Integral LED Diffusalite component photograph. Right: Ansell prismatic batten accessory illustration. Separate products, not a retrofit pair. [76, 69]

Mechanism. A diffusing surface spreads light and can lower visible brightness peaks. Prismatic facets refract light to change its angular distribution; a clear textured cover is not necessarily a diffuser or an opaque shield. [17, 75]

Choose the complete fitting. Seek an emitting surface that appears suitably even from occupied positions, with enough optical control for the view. The Integral range describes a larger prismatic surface; this is a supplier design claim, not a measured glare result here. [76]

Trade-off. Transmission and redistribution can reduce task light or send more light towards the eye. Check output, the complete intensity distribution and source appearance. A broad luminous panel can still be too bright. [15, 14, 75]

For strips, avoid a visible row of intense LED points. Select actual emitting brightness, optics and placement together; a strip or cover is not automatically glare-free. [14, 35, 73]

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D.12 A floodlight needs optical control

Fitting and accessory illustrations

EXPOSED OPTICAL FACE



FAMILY EXAMPLE WITH HOOD



GLARE SHIELD



WIRE GUARD

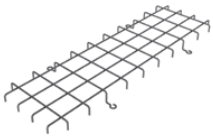


Figure 44: A rectangular LED floodlight, a hooded family example and separate accessories. Manufacturer images: ABOVE ALL Lighting. The guard and glare shield are distinct accessories. [72]

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The glare risk. An exposed LED floodlight aimed towards a route can send intense light into approaching views. The aperture, mounting and aiming need consideration together. [12, 14]
Useful controls. Re-aim or relocate the fitting; where needed, choose a compatible hood, visor, louvre or different distribution that restricts unwanted light. [12, 14]
The important distinction. The illustrated wire guard is an open mechanical barrier. Its presence does not establish that the bright optical face is screened. Assess the actual source-to-eye path. [15, 72]
What to retain. The required ground, person, equipment and sign surfaces must remain lit. Fitting shape, price and a broad beam alone do not determine suitability.
These are product illustrations, not a field before/after test. The hooded image is from the manufacturer's gallery; exact model/version correspondence is not independently established.

D.13 Choose the distribution, not just the beam label

Luminaire catalogue / asymmetric and ultra-wide products

AREA-FLOODLIGHT OPTICAL FACE **180-DEGREE VARIANT: LSG0225180**





Figure 45: Manufacturer images: Thorn Areaflood Pro optical-face photograph; Vision X LSG0225180 official product illustration. Different families, not a performance ranking. [77, 78]

Controlled coverage. Asymmetric optics can place useful light forward across an assigned area while the fitting remains appropriately aimed. Select the complete optic, mounting and output; flat glass alone does not indicate poor glare control. [12, 75, 77]

What 180 degrees tells us. Vision X lists an ultra-wide 180-degree option. The selected catalogue page does not define it as a horizontal/vertical acceptance angle. Obtain the matching photometry and definition; a beam label alone cannot predict light entering a worker's eyes. [78]

Action and trade-off. Avoid an exposed bright face directed at occupied views. Use suitable optics, shielding, aim and output. A narrower beam can also be intense or create dark gaps; address gaps with appropriate positions rather than indiscriminately increasing reach. [15, 12, 14, 17]

Neither a wide beam nor a rectangular housing proves glare. Assess intensity towards actual eye positions and maintained task illumination. No universal throw distance or mounting angle is proposed.

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D.14 Give each fitting a defined area to serve

Supplier yard extension / design view and installed photograph

DESIGN SIMULATION, NOT A PHOTOGRAPH **INSTALLED YARD, AS PUBLISHED**

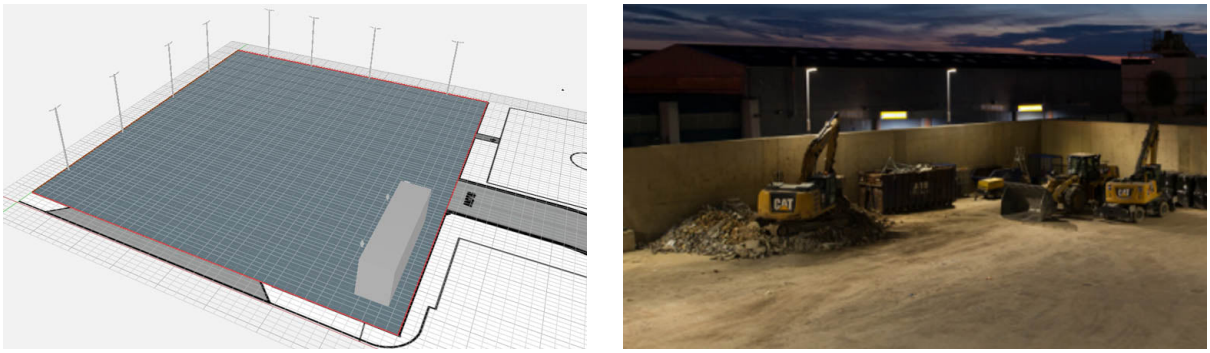


Figure 46: Water Treatment Works yard: Wydels Electrical design view and installation photograph. This is not a before/after glare comparison. [79]

Reported change. The site added aggregate storage and moved to round-the-clock operation. Wydels describes supplementing existing building lighting with additional column-mounted fittings to cover the new areas. [79]

Design lesson. Define routes, storage work and vehicle/pedestrian interfaces. Assign light to those zones using suitable distributions and positions. Add lighting where obstructions or range leave required detail dark; avoid tilting one bright floodlight towards people to chase distant coverage. [12, 14, 17]

Check the combined view. Include approaching drivers, helpers and workers looking towards the building. Retain useful vertical and ground illumination while controlling the combined sources, shadows and reflections. More fittings can add glare if their faces remain exposed. [15, 12, 14]

The installed image shows the arrangement, not measured glare performance. Supplier output, spacing and lux figures are not adopted as mining criteria.

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D.15 Distribute useful light along the work

South African mine case-study photographs

DISHABA: WITHOUT STRIP LIGHTING **DISHABA: WITH STRIP LIGHTING**



Figure 47: Dishaba comparison photographs: Anglo American Platinum (2017), reproduced from MOSH. [35]

The design approach. Several suitably placed lower-output fittings, or a longer emitting strip, can distribute useful illumination instead of concentrating it into a few intense sources. This is a design option to evaluate. [3, 29, 14]

What the mines reported. At Eland the visit team described even illumination with no observed glare. At Dishaba they recorded dark gaps at connectors. MOSH also advises positioning strips outside direct sightlines. [35]

What to retain. Choose source brightness, optics and position for the actual work. Verify face detail, footing and connector gaps. Exposed points or an intense visible strip can still cause glare.

The related Eland workface photographs are already shown in Figure 19; they are retained there once.

The photographs illustrate coverage and mine practice. They do not isolate the effect of lower source luminance or measure comparative glare. Eland and Dishaba findings must not be combined into one tested result.

DRAFT

D.16 Recess the source and soften its contrast

Published configuration examples - different interiors

LENSED FITTINGS AT THE CEILING PLANE **LENSED FITTINGS ABOVE THE CEILING PLANE**



Figure 48: Source photographs comparing flush lensed lighting and a historical coffered arrangement. Left photograph courtesy of Finelite Inc.; right from IES DG-18-08. These are different interiors, not a before-and-after renovation pair. [31]

The approach. A recess or surrounding structure can reduce exposure of a bright emitting surface from some views. Suitable room surfaces and indirect lighting can also soften brightness differences. [11, 3, 31]

A useful application. In a workshop, office or control room, consider source concealment together with light on the task and surrounding surfaces. Confirm that luminous lenses and reflector images do not create another bright patch. [15, 23]

What to retain. Recessing must not cut off the useful beam or maintenance access. Reflective-ceiling examples depend on suitable surfaces; they cannot be copied directly into a dark excavation.

The photographs explain two physical arrangements. No glare rating or comparative performance was measured for this review.

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D.17 Move the reflection away from the information

Published photographs illustrating a masking reflection

Figure 5 in Section 4.3 already illustrates a reflection masking printed or displayed information. It is retained there once. The reviewed SLL book photographs are preserved in the supporting review package; another printed-page comparison is not repeated here.

A lamp image can mask detail even while ample light reaches the surface. The relationship between source, glossy surface and observer determines where the reflection appears. [15, 3]

Move a masking reflection away from the detail. At the workshop gauge, identify the source whose image crosses the pointer or graduations. Change its position or direction so that the image misses the normal viewing positions while light still reaches the scale. Where the equipment permits, changing gauge orientation or an appropriate surface finish can also help. Do not modify protective windows, coatings or mandatory markings without the relevant equipment approval [15, 3].

If relocation is impossible, a different distribution or selective screening may reduce the reflected image. Additional task light can sometimes improve scale illumination without brightening the offending reflection, if placed outside that reflection path. Adding a lamp in the same path can strengthen the masking patch [15].

The desired result is a readable scale over the required range of head positions, without new glare for nearby workers. For inspection of a polished component, a deliberate reflection may instead reveal an uneven finish. Select the arrangement for the information sought rather than eliminating every highlight [16].

Retain the task information. The scale, label or display must remain readable over the required viewing range. Preserve protective windows and markings. Some inspection tasks deliberately use highlights to reveal defects, so eliminate only reflections that defeat the task. [15, 3]

The correction depends on source, surface and observer geometry. The supporting comparison shows the condition with and without a reflection; it does not identify one physical intervention between photographs.

DRAFT

D.18 Choose optics and output together

Laboratory configuration comparison with observer evidence

Figure 25 and Section 7.4 already present the Saturn arrangements and position-specific laboratory results. The photographs remain there once; the glare findings come from the study rather than from their appearance.

What the comparison establishes. Thirty participants assessed discomfort and contrast sensitivity at two roof-bolter positions. The front-position results favoured the tested Saturn arrangements; middle-position differences were not significant. [30]

Select distribution and output for the task and view. The source tested several Saturn outputs using neutral-density filters. It did not establish a universal dimmer setting or isolate one optical change as the sole cause. [30]

Preserve the floor, cable and neighbouring work. An opaque shield can reduce glare and also remove useful light. USBM describes rear machine lights for which shielding left the floor and cables too dark; a diffusing arrangement gave a better compromise. The transferable lesson is to compare task and observer paths together, not to prescribe that diffuser for another machine [14].

For the underground example, if a shield hides the fitting but darkens the next foothold, change the shield/optic geometry, relocate the fitting or give the foothold a separate protected light. Dimming the entire installation is incomplete if it removes required route coverage. Use compatible engineered components and retain equipment approvals and protection conditions.

Use a glare rating within its method. For suitable indoor installations, the source's tabular Unified Glare Rating (UGR) method assesses discomfort under defined room, reflectance and layout conditions. It is not a fixed product property guaranteeing comfort in every mounting and does not assess disability glare. ISO/CIE guidance distinguishes point calculations for comparing options from the conditions used to establish tabular limiting criteria [23, 11].

Outdoor Glare Rating (GR) has different observer and environmental assumptions. Use the relevant method for the relevant views. Do not substitute indoor UGR limits for machine headlamps or assume a normal outdoor model represents an upward view or wet reflective scene. Where the method does not cover the situation, retain that limitation and evaluate the actual task/view arrangement without claiming conformity from an unrelated index [12, 59].

No universal dimming percentage, shielding geometry or mining glare limit is established by this example.

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GLOSSARY AND SYMBOLS

Visual task
The information a person needs to see to perform an activity.

Illuminance, E (lux, lx)
Light arriving per unit area on a specified surface.

Luminance ($\mathrm{cd/m^2}$)
Light from a surface in a specified viewing direction; distinct from illuminance and subjective brightness.

Reference value
A selected source-based numerical recommendation with stated application and conditions.

Maintained illuminance
A value intended to be sustained over the service period under the stated maintenance basis; retain the source's statistical definition.

Average illuminance, E_{avg}
The spatial average over the defined area, estimated by an appropriate sampling method.

Minimum illuminance, E_{min}
The lowest relevant value; distinguish a sampled minimum from the unknown minimum between sampled points.

Uniformity, U_0
Commonly the ratio $E_{\mathrm{min}}/E_{\mathrm{avg}}$ on a defined area. Other ratios must be identified.

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Glare
Brightness conditions that cause discomfort or interfere with seeing.

General / localised / task lighting
Provision across a space / concentrated at work areas / directed at a particular task.

Task plane
The surface and orientation relevant to the information being seen or measured.

Verification
Checking a stated specification under defined conditions.

Validation
Establishing whether the recommendation supports its intended outcome across the relevant conditions; not established by a lux reading alone.

Source abbreviations
MVSSA: Mine Ventilation Society of South Africa; SANS: South African National Standard; CIE: International Commission on Illumination; IES: Illuminating Engineering Society; USBM: United States Bureau of Mines; LED: light-emitting diode.

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