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1. INTRODUCTION

Environmental influences impact the ageing of process control systems on power stations. To ensure long term system reliability it is important that this equipment be maintained within the environmental parameters as specified by its manufacturers.

This standard aims to provide practical requirements to plant engineers and maintainers to establish and maintain a suitable environment for the Storage, Transport and Operation of Process Control Electronic Equipment at Eskom's coal-fired and Peaking power stations.

2. SUPPORTING CLAUSES

2.1 SCOPE

The standard covers the environmental conditions for the Storage, Transport and Operation of all Process Control Electronic Equipment at Eskom's coal-fired and Peaking power stations.

2.1.1 Purpose

The purpose of the standard is to ensure that the long term integrity of all Process Control Electronic Equipment at a power station is maintained during Storage, Transport and Operation.

2.1.2 Applicability

The standard is applicable to all Process Control Electronic Equipment at all Eskom power stations.

The following equipment is excluded from this standard:

- Field measuring devices.
- Special applications e.g. intrinsically safe equipment, hazardous areas, and equipment that require special conditions.

2.2 NORMATIVE/INFORMATIVE REFERENCES

The following normative reference documents contain provisions that, through reference in the text, constitute requirements of this standard. These references are subject to revision and users are responsible to ensure that the most recent edition of the documents listed below is used;

2.2.1 Normative

[1] ASHRAE 52.1-1992 Gravimetric & Dust –Spot Procedures For Testing Air Cleaning Devices Used In General Ventilation For Removing Particulate Matter

[2] ASHRAE 52.2-2007 Method Of Testing General Ventilation Air-Cleaning Devices For Removal Efficiency By Particle Size.

[3] EN 779:2012 Air Filter Test Standard.

[4] 240-54937450 Fire Protection & Life Safety Design Standard.

[5] 240-77196650 Mitigation of MUT C&I Risks through Effective Operating & Maintenance Strategies

2.2.2 Informative

[6] IEC 60721-3-1 Classification of groups of environmental parameters and their severities; Storage.

[7] IEC 60721-3-2 Classification of groups of environmental parameters and their severities; Transportation.

[8] IEC 60721-3-3 Classification of groups of environmental parameters and their severities; Stationary use at weather protected locations

2.3 DEFINITIONS

Definition	Description
Process Control Electronic Equipment	It is the collective term for all control system hardware, which represents all field measuring interface modules, automation processors, communication networks, computer based operator interface equipment including servers, plant information system and system engineering and diagnostic tools installed on a power station.
Storage	The term Storage defines the environmental conditions Process Control Electronic Equipment is stored under in a dedicated location for periods longer than three months (long-term).
Transport	The term Transport defines the environmental conditions Process Control Electronic Equipment is moved under from location A to B. This typically represents a time period of less than three months.
Operation	The term Operation defines the environmental conditions permanently installed Process Control Electronic Equipment (firmly mounted equipment installed in a dedicated location) is operated under. It further includes the short period of handling during erection work, downtime, maintenance and repair at a different location

2.3.1 Disclosure Classification

Controlled Disclosure: Controlled Disclosure to External Parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation	Description
ASHRAE	American Society of Heating Refrigeration and Air-Conditioning Engineers
EMI	Electromagnetic Interference
HVAC	Heating, Ventilation And Air Conditioning
IP	Ingress Protection
MERV	Minimum Efficiency Reporting Value
Pa	Pascal

2.5 ROLES AND RESPONSIBILITIES

- The Lead Design Engineer shall be responsible to ensure that this standard is implemented on new projects.
- The Design Review Team checks compliance to this standard during the various stages of review as part of the project lifecycle model (PLCM)
- The C&I CoE Manager/elected representative will check compliance to this standard by auditing each BU from time to time.
- The C&I Engineering Manager of each BU ensures compliance to this standard by developing BU-specific procedures as described in section (3.5)

2.6 PROCESS FOR MONITORING

The document shall be updated in accordance with the Eskom document review process or as business needs change.

2.7 RELATED/SUPPORTING DOCUMENTS

See Normative/Informative references

3. ENVIRONMENTAL CONDITIONS FOR PROCESS CONTROL EQUIPMENT USED AT POWER STATIONS STANDARD

3.1 REQUIREMENTS

3.1.1 Storage

The following conditions are required for the Storage of Process Control Electronic Equipment:

- The equipment shall be stored in their original packaging in dedicated storage rooms.
- The ambient temperature of the storage room shall not fall outside the temperature range of 5ºC to 40ºC and the maximum allowable temperature rate of change shall not exceed 0.5ºC per minute, averaged over a 5 minute time period. In cases where these requirements cannot be maintained, the temperature in the room shall be controlled via heating and cooling. For such air-conditioned rooms the temperature shall be controlled at 22ºC ± 2ºC.
- The relative humidity in storage rooms is generally not controlled. Should the ambient relative humidity in the room however fall outside the range of 5% to 85% at any point in time, it shall be controlled within the range of 20% to 75%.
- The equipment shall be protected against the detrimental influences of sand and dust. The ingress of sand is not permitted and the presence of dust is prevented by means of sealing of the building, the original equipment packaging or by adding additional packaging to the original packaging, in which the components were shipped from the manufacturer.
- Special precaution against chemical conditions is necessary in the event of contaminant levels exceeding normal levels due to industrial activity. Where the ingress of aggressive gasses (such as gaseous sulphur compounds) is present, these gasses shall be kept out by means of suitable packaging or by appropriate filters fitted in the supply air duct of the air conditioning system. In such cases corrosion monitors shall be installed and monitored.
- The equipment shall not be stored in areas where significant shock and vibration is present. As a maximum components can be exposed to vibration and shock transmitted from machines or passing vehicles in the vicinity of the storage area. In locations where high levels of vibration are present, additional packaging shall be applied to damp any vibration the components will be exposed to.
- The exposure of equipment to condensation, water and icing is under no circumstances permitted.
- It should be noted that climatic conditions inside buildings are dependent on the outside open air conditions, especially air temperature and the type of building construction. Walls with good thermal insulation or high thermal capacity can continuously smooth peaks of outside temperature variations between day and night, or those produced over a longer period of time. Walls with poor thermal insulation or low thermal capacity cannot have this effect, and peaks can be magnified due to the effect of solar radiation during the day, and the effect of building radiation at night.

3.1.1.1 Store room requirements

In addition to the Storage conditions specified above, the following aspects shall be taken into account during the design or maintenance of store rooms:

- Store room access shall be controlled and limited to authorised personnel only.
- Layout of storage racks and equipment shall promote easy access, evacuation and the minimal handling of equipment.
- A procedure shall be available to store room personnel for the handling of Process Control Electronic Equipment to prevent damage during the handling of equipment and components.
- There shall be sufficient illumination in the room, which conform to the requirements specified in the Occupational Health and Safety Act.
- Smoking inside store rooms is prohibited.
- All storage racks and equipment shall be securely mounted.
- There shall be no obstacles in the room. Free-standing equipment shall be kept in specially demarcated areas.
- Surface finishes (walls and floors) shall promote hygiene and have dust binding properties.
- Fire-fighting equipment shall be available inside or at the entrance of the storage area and appropriate for electronic equipment.
- Be aware of other infrastructure in the room e.g. water pipes, electrical network etc. Assess the risk of these infrastructures and take appropriate action.

3.1.2 Transportation

The following conditions are required for the Transportation of Process Control Electronic Equipment:

- The equipment shall be transported in their original packaging, in which they were shipped from the manufacturer.
- The equipment is allowed to be transported in ambient temperatures ranging from –40ºC to +70ºC for unventilated containers and –40ºC to +40ºC for ventilated containers. In order to prevent any condensation on the components, the packaging may only be opened at the location where they will be installed, after the temperature has been equalised.
- The equipment is allowed to be transported in the humidity range of 5% to 95%. In environments outside this range the packaging of the equipment shall be suitable to prevent any condensation on icing.
- During handling and transport the equipment shall be protected from being mechanically damaged by means of additional packaging suitable for the particular type of handling and transport to be used.
- The direct exposure of the equipment to condensation, water and icing during transport is not permitted.
- Components can be transported by air, sea or land transport.

3.1.2.1 Transport, moving and receiving requirements

In addition to the Transport conditions specified above, the following aspects shall be taken into account during the transport and receiving of the equipment:

- Throughout the transit process, the environment shall be monitored and corrections made.
- Guidelines for moving equipment;
- Check the maximum equipment dimensions against possible obstacles. These may include narrow hallways, restricted doorways and small elevators.
- Check the availability and readiness of any necessary devices for moving the equipment.
- Delays can be avoided by giving the delivery carrier advance notice of any special requirements.
- When unpacking the equipment, check the shipment against the invoice.
- When it is necessary to temporary store the equipment before installation, it shall be stored with its original packaging intact to minimize humidity. In the event of equipment being unsealed for verification, more desiccant shall be added to the packaging before it is resealed. The temporary storage area shall not subject the equipment to environmental conditions beyond those listed in this document.
- After delivery the equipment shall be stored in an environmentally controlled storage area or equivalent.
- The equipment delivery needs to be concurrent with the completion of the respective room it will be installed in.

3.1.3 Operation

The following conditions are required for Process Control Electronic Equipment in Operation:

1. In locations with controlled environmental conditions (Equipment, server and engineering rooms):

- The equipment shall be installed in cubicles in dedicated equipment rooms in the plant. The degree of protection of the cubicles shall be suitable for the environment of the location, which typically will be IP20.
- The ambient temperature in equipment, server and engineering rooms shall be controlled at 22ºC ± 2ºC, with a maximum rate of change of not more than 0.1ºC/min averaged over a 5 minute time period.
- The relative humidity at the respective rooms shall be within 20% to 75%.
- The relative humidity shall be controlled in the range of 40% to 60% where heating is added for human comfort in areas such as control rooms.
- The equipment shall be protected against the detrimental influences of sand and dust. The ingress of sand is not permitted. Dust ingress shall be prevented by means of facilities in the buildings/enclosures the equipment is installed in (for example pressurisation, and dust filters, dust lobbies etc.). The levels of dust permitted shall not exceed 0.2 mg/m^3 dust suspension and 1.5 mg/m^2/h for sedimentation.
- Special precaution against chemical conditions is necessary in the event of contaminant levels exceeding the normal levels from both process and non-process sources. Where the ingress of aggressive gasses (such as gaseous sulphur and chlorine compounds) is present in a controlled environment, these gasses shall be kept out of the air conditioning system by appropriate filters fitted in the supply air duct. In such cases corrosion monitors shall be installed and monitored.

- The equipment can be exposed to reasonable levels of vibration and shock, such as those transmitted from machines or passing cranes in the vicinity. In locations where high levels of vibration are present, vibration damping shall be added to the equipment installation.
- The exposure of equipment to condensation, water and icing is not permitted

2. In Un-controlled ambient conditions (Typically sub stations, switchgear rooms, turbine floor etc.)

- The equipment shall be installed in enclosures at dedicated locations in the plant. The degree of protection of the enclosures shall be suitable for the environment condition of the location, which typically will be IP 54 or better.
- The ambient temperature of these locations shall not fall outside the range of 5ºC to 40ºC and the maximum rate of temperature change should not exceed 0.5ºC per minute averaged over a 5 minute time period. In the cases where these requirements cannot be maintained, the equipment shall either be installed equipment rooms with a controlled environment or the equipment shall be suitable by design to operate under the actual conditions of the specific location.
- The operating temperature of equipment in the enclosures shall not exceed the maximum operating temperature specified by the manufacturer.
- The relative humidity at these locations is generally not controlled. In cases where the relative humidity falls outside the range of 5% to 85%, appropriate precautions shall be taken.
- The equipment shall be protected against the detrimental influences of sand and dust. The ingress of sand is not permitted. Dust ingress shall be prevented by means of facilities in the buildings or the enclosures the equipment is installed in (sealing, forced circulation and pressurisation, dust filters etc.).
- Special precaution against chemical conditions is only necessary in the event of contaminant levels exceeding the normal levels from both process and non-process sources. Ash and water treatment plants are examples of such areas, and the equipment in these plants should be protected by means appropriate enclosures capable of withstanding the chemical conditions present.
- The equipment can be exposed to reasonable levels of vibration and shock, such as those transmitted from machines or passing cranes in the vicinity. In locations where high levels of vibration are present, vibration damping should be added to the equipment installation.
- The exposure of equipment to condensation, water and icing is not permitted. In locations where water spray and splashing is present, enclosures shall be of the class that will prevent water getting in contact with the equipment.

3.1.4 Additional Monitoring Requirements of Environmental Conditions

In addition to the environmental conditions specified above, the following represents a number of additional requirements that shall be taken into account during the design or maintenance of dedicated equipment rooms:

- The ambient air temperature and the relative humidity in equipment, server and engineering rooms shall be monitored, recorded and alarmed for action. Alarm values shall be set to 70% relative humidity and 26ºC for temperature. In addition to this requirement, it is recommended that with new equipment installations the temperature in each equipment cubicle is also monitored. Dry bulb temperature should be kept within 15ºC to 30ºC.

Differential pressure between the Equipment room and the outside shall be monitored, with an alarm when this drops below 25Pa with all doors closed.

Room make-up air for pressurization should be not less than 15% of supply air volume or 2 two air changes per hour whichever is smaller.

3.2 APPLICATION OF ENVIRONMENTAL STANDARDS

a. The aim of this section is to provide the reader with an example of the application of an environmental standard. It further provides a brief description of the methodology followed by both the manufacturer and the user in the design and application of equipment. For a detailed description, the reader should study the reference documents specified in Section 2.2.

b. It also provides the reader with a guideline to the type of enclosures applicable to the different environments within a Power Station.

3.2.1 Environmental Influences

a. Equipment manufacturers design their equipment to standards classifying and defining environmental influences. These standards typically define categories of usage and classify groups of environmental parameters and their severity's (maximum limits) to which products should be subjected. Equipment users in turn classify the environment the equipment will operate in, by referring to the same standards and only then select equipment suitable for the application. It should be noted that equipment suitable for operation under harsh conditions is often expensive and it is common practice (economic decision) to provide equipment rooms for the equipment to be installed in. The design of these rooms will then follow the environmental requirements of the equipment it has to accommodate.

b. The European standard, IEC 60721-3 is an example of such an environmental standard and the table below refers to, in terms of the above standard, the classification for process control electronic based automation equipment.

Table 1: Environmental Influences (according to IEC 60721-3)

Usage Categories	Storage	Transportation	Operation
Climate conditions	Class 1K2	Class 2K4	Class 3K2
Chemical conditions	Class 1C2	Class 2C2	Class 3C2
Mechanical activity	Class 1S1	Class 2S1	Class 3S2
Mechanical characteristics	Class 1M3	Class 2M3	Class 3M4

3.2.2 Storage

The most important specifications for the storage of process control electronic equipment, in terms of standard IEC 60721-3-1, are detailed below:

Table 2: Storage 1

Climatic Condition	Class 1K2
Ambient temperature	5ºC to 40ºC
Relative Humidity	5% to 85% without condensation
Air pressure	106kPa to 70kPa (-1000m to 3000m altitude)
Exposure to rain, water, condensation, frost and ice	Not permitted

Table 3: Storage 2

Chemical Active Conditions	Class 1C2
Sulphur dioxide, SO_2	Mean value: 0.3 mg/m^3
Hydrogen sulphide, H_2S	Mean value: 0.1 mg/m^3
Chlorine, CL_2	Mean value: 0.1 mg/m^3
Hydrogen chloride, HCL	Mean value: 0.1 mg/m^3
Hydrogen fluoride, HF	Mean value: 0.01 mg/m^3
Ammonia, NH_3	Mean value: 1.0 mg/m^3
Ozone, O_3	Mean value: 0.05 mg/m^3
Nitrogen oxides, NO_x	Mean value: 0.5 mg/m^3

Table 4: Storage 3

Mechanically Active Conditions	Class1S2 (with deviation*)
Sand	No presence of sand*
Dust (proportion of suspended matter)	0.2mg/m^3
Dust (deposited)	1.5 $mg/(m^2h)$

Table 5: Storage 4

Mechanical Conditions	Class1M3	
Stationary vibration, sinusoidal:		
- Displacement amplitude	3mm (5 to 8Hz)	
- Acceleration amplitude		10 m/ s^2 (8 to 200Hz)
Non-stationary vibration, including shock:		
- Displacement amplitude	.075 mm (5 to 58Hz)	
- Acceleration amplitude		10 m/ s^2 (58 to 200Hz)

3.2.3 Transport

The most important specifications for the storage of process control electronic equipment, in terms of standard IEC 60721-3-2, are detailed below:

Table 6: Transport 1

Climatic Condition	Class 2K4
Minimum ambient temperature	-40ºC
Maximum ambient temperature:	
In unventilated containers	70ºC
In ventilated containers, or uncovered	40ºC
Relative Humidity	5% to 95% without condensation
Air pressure	106kPa to 66kPa (-1000m to 3500m altitudes)

Table 7: Transport 2

Chemical Conditions	Class 2C2
Sulphur dioxide, SO_2	Mean value: 0.3 mg/m^3
Hydrogen sulphide, H_2S	Mean value: 0.1 mg/m^3
Chlorine, CL_2	Mean value: 0.1 mg/m^3
Hydrogen chloride, HCL	Mean value: 0.1 mg/m^3
Hydrogen fluoride, HF	Mean value: 0.01 mg/m^3
Ammonia, NH_3	Mean value: 1.0 mg/m^3
Ozone, O_3	Mean value: 0.05 mg/m^3
Nitrogen oxides, NO_x	Mean value: 0.5 mg/m^3

Table 8: Transport 3

Mechanically Active Conditions	Class 2S2
Sand in the air	No presence of sand, or preventative measures are taken
Dust	No presence of sand, or preventative measures are taken (0.2mg/m^3)

Table 9: Transport 4

Mechanical Conditions	Class 2M3	
Stationary vibration, sinusoidal:		
- *Displacement amplitude*	7.5mm (5 to 8Hz)	
- *Acceleration amplitude*		20 m/ s^2 (8 to 200Hz)
Stationary vibration, random:		
- *Acceleration spectral density*	3 m^2/s^3 (10 to 200Hz)	1m^2/s^3 (200 to 2000Hz)

3.2.4 Operation

The most important specifications for the operation of process control electronic equipment, in terms of standard IEC 60721-3-3, are detailed below:

Table 10: Operation 1

Climatic Condition	Class 3K2 (with deviation*)
Ambient Temperature (summer)	20ºC to 25ºC controlled
Ambient Temperature (winter minimum)	15ºC
Relative Humidity	20% to 75% without condensation
Fluctuation in temperature	0.5ºC/min, averaged over a 5 min period
Movement of surrounding air	0.5 m/s
Air pressure	106kPa to 70kPa
Exposure to condensation, water and icing	Not permitted

Table 11: Operation 2

Chemical Conditions	Class 3C2
Sulphur dioxide, SO_2	Mean value: 0.3 mg/m^3
Hydrogen sulphide, H_2S	Mean value: 0.1 mg/m^3
Chlorine, CL_2	Mean value: 0.1 mg/m^3
Hydrogen chloride, HCL	Mean value: 0.1 mg/m^3
Hydrogen fluoride, HF	Mean value: 0.01 mg/m^3
Ammonia, NH_3	Mean value: 1.0 mg/m^3
Ozone, O_3	Mean value: 0.05 mg/m^3
Nitrogen oxides, NO_x	Mean value: 0.5 mg/m^3

Table 12: Operation 3

Mechanically Active Conditions	Class3S2 (with deviation*)
Sand	No presence of sand*****
Dust (proportion of suspended matter)	0.2 mg/m^3
Dust (deposited)	1.5$mg/(m^2h)$

Table 13: Operation 4

Mechanical Conditions	Class3M4	
Stationary vibration, sinusoidal:		
- *Displacement amplitude*	3mm (2Hz to 9Hz)	
- *Acceleration amplitude*		10 m/s^2 (9Hz to 200Hz)

Attention is drawn to the fact that combinations of the environmental parameters given may increase the effect on a product. This applies especially to the presence of high relative humidity in addition to conditions of chemically or mechanically active substances

3.2.5 Enclosure Classification

The IP (Ingress Protection) Code describes a system for classifying the degrees of protection provided by the enclosures of electrical equipment. Developed by the European Committee for Electro-technical Standardisation (CENELEC), these standards are designed to numerically rate an electrical product on the level of protection its enclosure provides. By assigning different number codes, the product's degree of protection can be identified quickly and easily. In the code IP 54, for example, IP identifies this standard, the 5 describe the level of protection from solid objects, and 4 describe the level of protection from liquids.

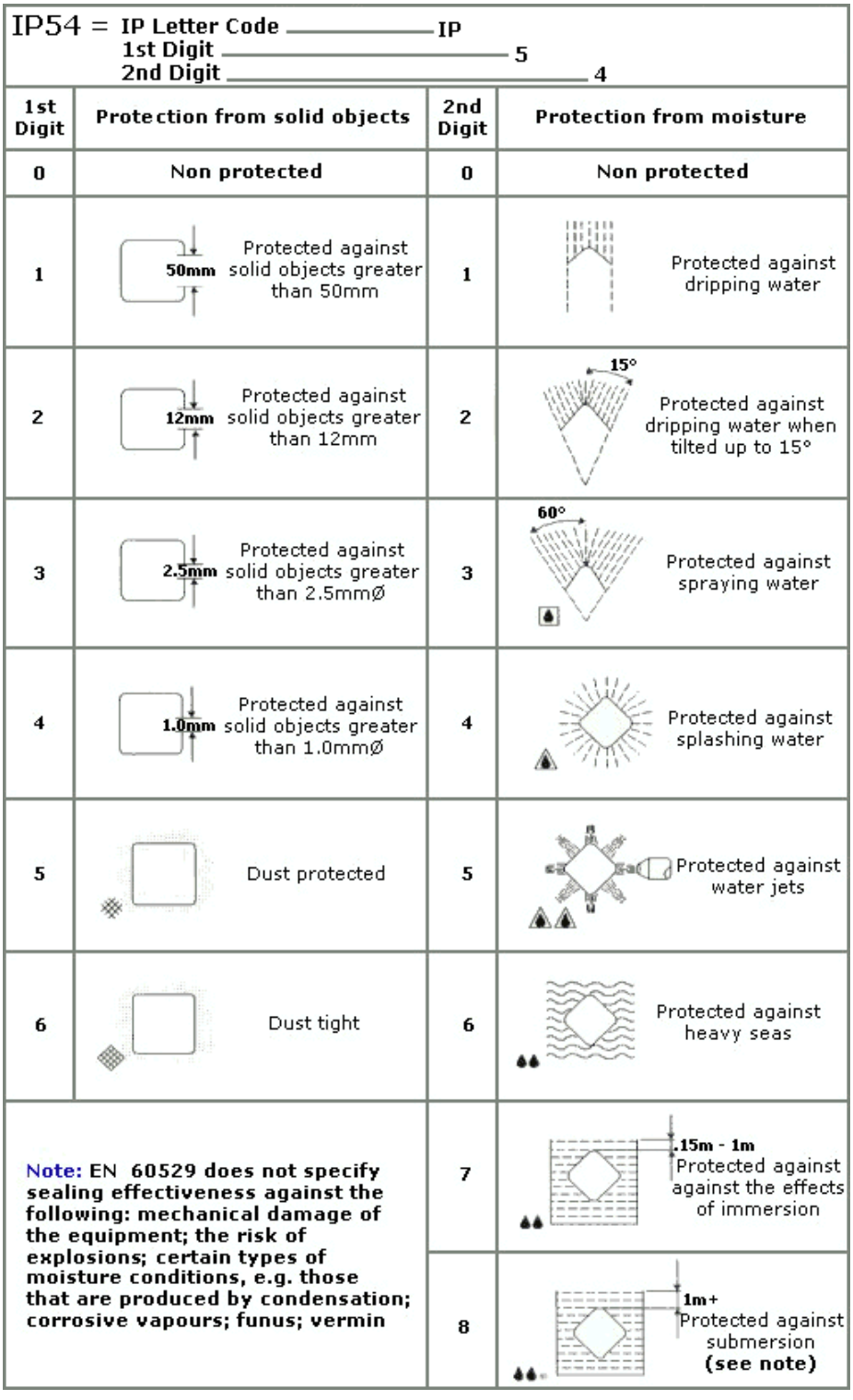

Figure 1: Enclosed Classification

3.2.5.1 Degrees of protection – First digit

The first digit of the IP code indicates the degree that persons are protected against contact with moving parts (other than smooth rotating shafts, etc.), and the degree that equipment is protected against solid foreign bodies intruding into an enclosure.

Protection level:

- 0 – No special protection
- 1 – Protection from a large part of the body such as a hand (but no protection from deliberate access); from solid objects greater than 50mm in diameter.
- 2 – Protection against fingers or other objects not exceeding 80mm in length and 12mm in diameter.
- 3 – Protection from entry by tools, wires, etc., with a diameter of thickness greater than 1.0mm.
- 4 – Protection from entry by solid objects with a diameter or thickness greater than 1.0mm
- 5 – Protection from dust levels that would interfere with the operation of the equipment.
- 6 – Dust tight.

3.2.5.2 Degrees of protection - Second digit

The second digit indicates the degree of protection of the equipment inside the enclosure against the harmful entry of various forms of moisture (e.g. dripping, spraying, submersion, etc.).

Protection level:

- 0 - No special protection requirement.
- 1 - Protection from dripping water.
- 2 - Protection from vertically dripping water.
- 3 - Protection from sprayed water.
- 4 - Protection from splashed water.
- 5 - Protection from water projected from a nozzle.
- 6 - Protection against heavy seas, and or powerful jets of water spray.
- 7 - Protection against immersion.
- 8 - Protection against complete continuous submersion in water. Submersion depth and time must be specified by the end user. The requirement must be more onerous than IP67

3.3 MAINTENANCE

- All recorded alarms shall be reported to the responsible Maintenance Artisan/Technician on duty.
- The condition of all equipment room shall be reported and recorded on a weekly basis at the Production Meetings with the corresponding corrective actions in place, where required.
- The SAP Maintenance schedule must incorporate a routine maintenance task allocated to the responsible maintenance discipline, to check the condition of the equipment rooms with respect to general housekeeping, the monitoring of potential “hot zones”, air locks, dust and water ingress and humidity effects.
- During all outages, all services to the equipment rooms such as HVAC, fire detection, access control, etc. will be maintained as in normal production. All cabinets and cabinet filters may be cleaned and replaced.

- The responsible plant engineer should assess the recorded environmental conditions via the plant historian (or other tools) and report this on a monthly basis to the Engineering Managers Meeting. All deficiencies shall lead to corrective measures to restore the environment to an acceptable condition.
- Floors and walls of all equipment rooms must be cleaned with a slightly damp mop/cloth to avoid dust suspension. This activity must be supervised by a responsible person to prevent damage to equipment.
- Each BU must develop their own site-specific procedure describing the management of this standard, including all responsible parties involved.
- Regular audits regarding compliance shall be administered by the C&I CoE.

4. AUTHORISATION

This document has been seen and accepted by:

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5. REVISIONS

Date	Rev.	Compiler	Remarks
September 2013	0.1	D.A. Govender	Document created from 36-776
May 2014	0.2	D.A. Govender	Draft Document for Revision
June 2014	1	D.A. Govender	Final Document for Authorisation and Publication
Oct 2017	1.1	K Sobuwa	Updated Sec 3.1.4 by deleting all Civil and General Building requirements to doc 240-56355541: C&I Computer & Equipment Rooms Civil and General Building Requirements Guideline;
January 2018	2	K Sobuwa	Final Rev 2 Document for Authorisation and Publication

6. DEVELOPMENT TEAM

The following people were involved in the development of this document:

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- H.J. Gerber - C&I Engineer – Plant Application
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7. ACKNOWLEDGEMENTS

J.J. Veldman is hereby acknowledged as the original compiler of document 36-776.

Devan Govender is hereby is acknowledged as 1st reviewer of this document.