International Journal of Information, Engineering & Technology

Volume 11, Issue 3, PP 73-78, ISSN: 2360-9194, December, 2020
Double Blind Peer Reviewed International Research Journal
garcjournalssubmit@gmail.com
Journal Series: Global Academic Research Consortium (garc)

Impacts of Environmental Factors on Electrical and Electronics Equipment and Devices

[1]Kalli B. Mai, [2]Ibrahim M. Harram, [3]Hamza Abba[3] and [4]Mohammed Dima Ali

[1,]Department of Electrical/Electronic Engineering Technology, Ramat Polytechnic, Maiduguri, Borno State, Nigeria
[2,3]Department of Electrical/Electronic Engineering Technology, The Federal Polytechnic, Damaturu, Yobe State, Nigeria
[4]Department of Mechanical Engineering Technology, Ramat Polytechnic, Maiduguri, Borno State, Nigeria

Abstract: *Varieties of climates prevail around the world in which electrical and electronic equipment and devices are expected to function. These equipment are often subjected to environmental shock, vibration and other factors during both normal use and testing. Such environmental factors can cause physical damage to parts that will result to total failure. Deterioration of system can vary considerably depending on environmental conditions encountered. These factors invariably influence the quality, reliability and lifespan of systems. This paper discusses various negative impacts experienced due to environmental factors on electronic and electrical systems in the North-Eastern part of Nigeria. Factors such as high temperature, relative humidity, solar radiation, sand dust, wind, rain and magnetic fields have adverse effects on EEE. Each environmental factor that is present requires a determination of its impact on the operational and reliability characteristics of the materials and parts comprising the equipment being designed. Possible solutions that can extend the lifespan and prevent untimely failure of these equipments and devices have been proffered.*

Key words: *Environmental factors, Negative impacts, Deterioration, Reliability, EEE*

1.0 Introduction

Electrical and Electronics Equipments (EEE) and Devices play an important role in the world today. The use of these Equipments and Devices in various spheres of human activity in such places like home, farms, gardens, recreations, workshops and laboratories (etc.) contributes largely to the development of complex scientific and technical know-how, increased productivity, improvements in communication and control systems, computer and instrument engineering, as well as wireless technology. Equipments and Devices are experiencing rapid development as a result of the emergence of the demand for sophisticated machines and global technological advancement. Their urgent need has

become essential in the present - day complex electronic and electrical systems which are used in transport, communication, industrial operation, military, medical, entertainment, research etc.

Electronic and electrical equipments and devices are expected to function in a variety of climates like tropical/arctic/desert conditions, high altitude, radiation, including transport hazards and mechanical shocks. These factors invariably influence the quality, reliability and life of electronic and electrical systems (Rao, 1998). A sustainable future for electrical and electronic equipment (EEE) is uncertain with rapid acceleration in technological advancements and resource consumption (O'Connel, 2013). In this paper, the general effects of various environmental factors on electrical and electronic systems in the North-Eastern part of Nigeria have been discussed. It covers various effects due to anyone or a combination of climatic factors may have on electronic/electrical equipments and materials.

2.0 CLIMATIC CONDITIONS AND THEIR EFFECTS ON ELECTRICAL AND ELECTRONIC EQUIPMENT

a. High Temperature

The prevailing climate in the North-Eastern part of Nigeria is known as the Local Steppe climate and semi-arid with an average temperature of 30◦c across the year (Accuweather, 2018). These high temperatures will result into the following negative impacts on EEE.

i. **Thermal ageing and oxidation:** This results in the loss of electrical quality and/or change of electrical properties like increase in power factor, decrease of dielectric strength and insulation failure.

ii. **Physical expansion:** Noticeable effects in form of Structural failure and differential expansion of different materials can cause distortion of assemblies, rupturing of seals and wear or binding on moving parts.

iii. **Loss or change of viscosity and evaporation:** This causes loss of lubrication properties, structural and/or mechanical failure (breakage or fracture, seizure).

iv. **Softening and melting of joined parts:** The internal temperature of equipment may approach a value where low melting point materials such as greases, protective compounds and waxes become soft or even begin to flow. This may lead to structural failure, physical breakdown or penetration of sealing may lead to internal electrical breakdown.

v. **Chemical decomposition:** With high temperatures, decomposition of organic material increases and rubber materials hardens. This may change the initial physical or electrical constants (Rao, 1998).

These factors results in physical or chemical change in the materials used and hence variation in characteristics of component. High temperature is considered the most destructive environmental factor associated with electronic/electrical equipments. Proper ventilation and air conditioning will go a long way in preventing the damages to be caused, thereby extending the lifetime of EEE.

b. Relative Humidity (Moisture Content)

Relative humidity RH is a measure of water vapour held in the atmosphere. Water vapour is intimately involved in the greenhouse because its concentration is linked with those of

other gases brought about by greenhouse gases. Changes and variations in RH in the lower levels of the atmosphere are critical to understanding changes in the hydrological cycle, including moisture content and precipitation (Dammo, 2016). With the RH and corresponding moisture content, EEE are affected negatively in the following ways:

i. **Moisture absorption and the deposition of damp layers:** Swelling, rupture of container and physical breakdown. Water is a good conductor and can act as a low resistance path on the insulation of electronic circuits. It has been observed that an ionized conducting film of water will form on the surface of a dielectric within a few seconds if the RH is 100%. This will lead to insulation break-down, change of dielectric properties and external electrical failure like tracking, insulation flashover etc. Only a few materials such as silicones, polystyrene and some polymers can stop the formation of a continuous moisture film but have poor resistance to fungal growths.

ii. **Corrosion:** This causes structural and/or mechanical failure that interfere with function, internal electrical failure and change of physical or electrical constants.

iii. **Electrolysis:** It causes loss of electrical properties and subsequent increase in the conductivity of insulators.

iv. **Loss of seals and the penetration of sealing:** Physical breakdown of sealing will lead to loss of electrical quality. A pressure seal must be incorporated in any component which has to be protected from high humidity. Edges of glass fibre material must be sealed to prevent moisture absorption by capillary attraction.

Relative Humidity of the environments can cause degradation of equipment performance since they promote corrosion effects in metallic components, the formation of surface films on nonmetallic parts that causes cause leakage paths and degrade the insulation and dielectric properties of these materials. Moisture absorption by insulating materials also can cause a significant increase in volume conductivity and the dissipation factor of these materials (NASA, 2000). Methods of averting these effects include use of hermetic sealing, moisture-resistant material, dehumidifiers, protective coatings and covering whenever not in use.

c. Altitude-high or low air pressure

(a) High Air Pressure: this will result in breakage or fracture of equipment, not only this but also external electrical failure like tracking, insulation flashover will occur.

Physical breakdown of sealing: this will result in Loss of electrical quality such as insulation and electrical breakdown.

(b) Low Air Pressure: conditions such as Low dielectric strength, insulations breakdown and flashover, corona and ozone formation, and overheating and fire risk will occur.

d. Solar Radiation

The sun is constantly giving off electromagnetic radiation (EMR) in all directions. When there is solar flare (high concentration of EMF pointed toward the earth), EEE are adversely affected in the following ways:

i. **Surface deterioration:** The EMR from the sun combined with heat dissipated by the components in the system can develop internal temperature well over 110°C. The Ultra-Violet solar radiation is of a much greater intensity in the region (Rao, 1998).

ii. **Change of initial physical/electrical properties:** The degradation of cable insulation will be considerably accelerated. The use of low melting point waxes should be avoided.

Appropriate shielding, the use of protective covers and solar refractors will go a long way in protecting EEE from the possible damage of solar flares.

c. Sand Dust and Wind

Dust is capable of hiding and accumulating inside the sockets, ports and other in-betweens of electronic product. If a barrier of dust is created, within those spaces, it may lead to the following:

i. **Clogging of parts:** This causes mechanical failure like seizure, wear or binding on moving parts.

ii. **Overheating:** The blockage of vents leads to overheating and subsequent leakage of dust through insulation.

iii. **Poor contacts in relays, switches and connectors:** This will result in loss of electrical quality and causing insulation flashover or breakdown of circuit

iv. **May cause arcing and carbon tracking in higher voltage appliances:** This will lead to insulation break-down, change of dielectric properties and external electrical failure like tracking, insulation flashover, open fire etc. (Dust Commander, 2018)

For most electronic appliances, constant cleaning of their parts and surfaces before use, covering while not in use and routine dusting will make them function well.

d. Rain

Pure water is a very poor conductor of electricity, but when it contains ions (sodium and chloride), it can act as a good conductor. When it comes in contact with active device, it makes several contacts that result in large current in the circuit. This will further result to:

i. **Corrosion:** Metals will corrode more rapidly and electrolyte action between dissimilar metals is considerably accelerated.

ii. **Distortion of materials:** An increase in the absorbed moisture leads to swelling of materials and both electrical and mechanical breakdowns can occur. Moisture absorbed by insulating material results in lowering of surface and volume resistivity.

iii. **Biological activity:** One of the end products of humidity/deposition of damp layer is growth of fungi. All organic materials are liable to deteriorate owing to the presence of moisture and nutrient causing fungous growths to form.

The presence of mould/fungi/insects can be destructive to electrical and electronic equipments. Such biological activity on the surface of materials will form a low resistance path resulting in loss of electrical quality and causing insulation flashover or breakdown of circuit (Rao, 1998). This can be overcome by keeping susceptible devices indoors with proper covering.

e. Magnetic Field

Electronic components like diodes, transistors, micro-controllers, microprocessors, wireless transceivers etc are affected in their function by the presence of magnetic fields (NASA, 2000). It results in induced magnetization with the following effects:

i. **Interference with function:** Active electronic components are affected in their function by the presence of magnetic fields.

ii. **Alteration of electrical properties:** It cause faults in electrical and electronic components. It can be responsible for loss of insulation resistance, warping of insulating materials, development of moulds, short circuits.

iii. **Induced heating of the contact:** This heating accelerates corrosion which increases the initial contact resistance and hence causes heating of the contact (NASA, 2000).

f. Desert condition

This can result in surface deterioration, the high ambient temperature combined with heat dissipated by the components in the system can develop internal temperature well over 110^{0}C. The solar radiation is of a much greater intensity in these regions. Change of initial physical and electrical properties coupled with degradation of cable insulation will be considerably accelerated (Rao. S, 1998).

g. Air - wind

Vibration; rocking and excessive movement: Structural failure like breakage or fracture. Physical breakdown of sealing may lead to electrical breakdown or loss of electrical quality (Rao. S, 1998)

g. Contamination

Contamination occupies an important place among the various chemical/physical mechanisms that cause faults in electrical and electronic components. It can be responsible for loss of insulation resistance, warping of insulating materials, short circuits, unwanted/poor or intermittent contacts etc. Electrolytic impurities derived from flux residues and impure supporting materials lead to corrosion in the base of ceramic resistors. Electrochemical and electrolytic corrosion of textile covered wires, connectors due to presence of acids and soluble salts in the coverings. Corrosion by hydrochloric acid released from overheated PVC coverings. Contact corrosion due to formation of black sulphide films on relay contacts in industrial area. Atmospheric pollution produces a tarnish film on the contact surface which increases the initial contact resistance and hence causes heating of the contact, this heating accelerates corrosion (Rao. S,1998)

3.0 CONCLUSION

The working condition of equipment and component parts can deteriorate considerably in different regions of the world depending on climates. Temperate regions (particularly those area known as rain forests in which there are high temperature combined with high humidity), desert area (where the highest temperature occur with wide variation between day and night including airborne dust/sand and the atmosphere has a very low moisture content), the arctic conditions (where very low temperature prevails for long periods) etc. forms the various climatic conditions of the study area.

Therefore, it is of utmost importance that electrical and electronic equipment and systems are so designed and manufactured to withstand the natural environmental factors and perform reliably well over a wide range climatic conditions with a fairly long lifespan.

References

Accuweather Forcast (2018): *https://m.accuweather.com*

Dammo, M. N., Yadima, S. G. and Sangodoyin, A. Y. (2016) *Observed Trend of Changes in Relative Humidity Across North-East Nigeria (1981-2010).* Civil and Environmental Research, Vol. 8 No. 3 pp 73-76.

Dust Commander (2018). *A Report on the Negative Effects of Dust on Electronics.*

National Aeronautics and Space Administration (NASA, 2000) *Preferred Reliability Practices: A Report on Environmental Factors (1978-1999).* Practice No. PD-EC-1101. Lewis Research Centre. *https://www.nasa.gov*

O'Connel, M. and Fitzpatrick C. (2013) *Re-Evaluate Re-Use of Electrical and Electronics Equipments (Evaluation and Mainstreaming).* A Report of Environmental Protection Agency (EPA) for Science, Technology, Research and Innovation for the Environment (STRIVE). *http://erc.epa.ie/safer/report*

Rao, S. U. M. (1998) *Influence of Environmental Factors on Component/Equipment Reliability.* Indian Journal of Engineering and Materials Science. Vol. 5, pp 121-123