



The use of 3D printing for high voltage applications and non-critical spares.

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Overview

- Introduction to 3D printing
- Overview of testing carried out
- Test results
- Non-critical spares case studies
 - Hot Stick attachment
 - Buccholtz Handles
- Implication for developing economies
- Future work

Introduction to 3D printing

- Additive Manufacturing Technique
- Better suited for:
 - High Complexity
 - Low volumes
- Various materials available
- Various levels of machines available
 - Entry level (Desktop)
 - Full commercial production

3D printing

- FDM – Fused Deposition Modelling
- Zortrax M200
- Desktop Variety

- Material Used
 - Zortrax ABS



Overview of testing carried out

The procedure used to test the 3D printed samples is based on IEC 60243-1 and BS EN 60243-1

- **Rapid rise test**
 - The test is carried out by increasing the voltage at a uniform rate from zero until breakdown occurs. The rate of rise should be selected so that breakdown occurs between 10 s and 20 s.
- **20 second step by step test**
 - This test is carried out by starting at 40% of rapid rise breakdown voltage. The voltage is applied for a period of 20 s. If the specimen withstands this voltage, the voltage is increased in incremental steps. Each increased voltage step is applied for 20 s until failure occurs.
- **Slow rate of rise test**
 - This test is carried out by starting at 40% of rapid rise breakdown voltage. The voltage will be increased at a uniform rate so that breakdown occurs between 120 s and 240 s.
- **60 second step by step test**
 - This test is carried out by starting at 40% of rapid rise breakdown voltage. The voltage is applied for a period of 60 s. If the specimen withstands this voltage, the voltage is increased in incremental steps. Each increased voltage step is applied for 60 s until failure occurs.
- **Very slow rate of rise test**
 - This test is carried out by starting at 40% of rapid rise breakdown voltage. The voltage will be increased at a uniform rate so that breakdown occurs between 300 s and 600 s.



Test setup



Test Results

kV	Ave	Test 1	Test 2	Test 3	Test 4	Test 5
Rapid Rise	27.88	25.7	26.3	28.2	30.1	29.1
20s Step	23.22	18.4	22.5	34.2	20	21
60s Step	27.04	30	37	21.2	22	25
120s Rise	21.88	22	21.4	21.2	20.8	24
300s Rise	20.22	20	19.8	20.3	20	21
Average of test averages				24.048 kV		
Standard Deviation				2.02796		

3D Printed	24kV
Oil Impregnated paper*	25kV



Hot Stick attachment



Buccholtz Handles

- Designed based on existing components.
- Additional strength reinforcements incorporated based on failure patterns detected.
- Minimal physical stock maintained, digital library is always available.

Implication for developing economies

- Reduce your total amount of physical spares held
- Maintain a digital database of designs
- Fleet of machines to manufacture parts on demand
- Modify design based on field requirements.
- Allows for in field design and manufacture of complex parts
- Access to technology drives innovation.

Future work

- Look at methods to improve dielectric strength
 - Oil Impregnated 3D printed objects.
- Mechanical testing of specimens
- Currently looking into practical applications for 3D printing.

Questions

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