

BRAZILIAN ARC FLASH LABORATORY

PETROBRAS Infrastructure Project

Dr. Márcio Bottaro

Project Leader

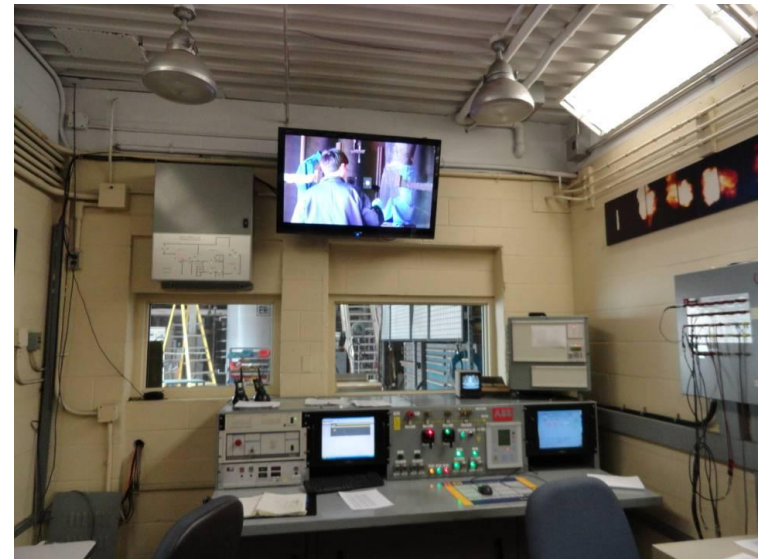
THE BRAZILIAN ARC FLASH LABORATORY PROJECT

- Petrobras Research and Development Program (2011)
 - Brazilian Laboratories for Arc Flash and Flash Fire
 - IEE/USP – High Current Tests Laboratory



THE BRAZILIAN ARC FLASH LABORATORY PROJECT

- **Petrobras Research and Development Program (2012)**
 - IEE/USP team visiting Kinectrics with Westex/Ideal support
 - **Dr. Márcio Bottaro**
 - **Eng. Jorge Nicolau Rufca, MsC**
 - **Dr. Hélio Eiji Sueta**
 - with Westex/Ideal support
 - **Maria do Carmo Chies**
 - **Josh Moody**



THE BRAZILIAN ARC FLASH LABORATORY PROJECT

- **Petrobras Research and Development Program (2012-2013)**

- IEE/USP team and Petrobras – Project Details and Submission

- **Dr. Márcio Bottaro (project Leader from IEE/USP)**

- **Maria Elizabeth Guimarães (Technical Support from Petrobras)**

- **Flavio Ribeiro (project Manager from Petrobras)**

THE BRAZILIAN ARC FLASH LABORATORY PROJECT

•Project Team (feb - 2014)

- Márcio Bottaro
- Ivan Bueno Raposo
- Eduardo Chinen
- Marcus Eduardo Piffer Amaral
- Rogerio Masaro
- Maurício Landi
- Luis Eduardo Caires
- Jesiel Rodrigues
- Danilo Cabral Rosendo
- Ildo Luiz Sauer
- Helio Eiji Sueta
- Araibe da Cruz Jorge
- Francisco Kameyama
- Jorge Nicolau Rufca
- Fernanda C. S. Soares
- Vlamir Viana
- Josemir Coelho dos Santos
- Celso Pereira Braz

THE BRAZILIAN ARC FLASH LABORATORY PROJECT

- **Petrobras Research and Development Program**
 - Brazilian Laboratories for Arc Flash and Flash Fire
 - IEE/USP – High Current Tests Laboratory
 - Equipment: R\$ 740,000.00
 - Infrastructure: R\$160,000.00
 - Professional support (2): R\$214,000.00
 - Contracted Services: R\$ 370,000.00

THE BRAZILIAN ARC FLASH LABORATORY PROJECT

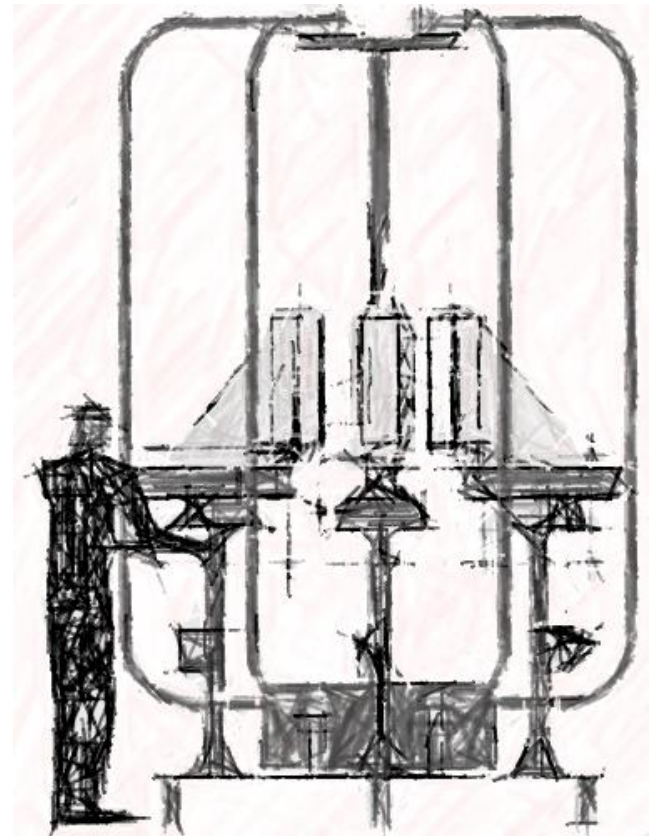
- **Petrobras Research and Development Program**
 - Brazilian Laboratories for Arc Flash and Flash Fire
 - IEE/USP – High Current Tests Laboratory
 - Total Budget – R\$ 1,484,000.00
 - First Part – R\$ 1,000,000.00 (on the go)
 - Second Part – R\$ 442,000.00 (2015)

TECHNICAL STANDARDS

- **ASTM F 1958, 1959, 2621 and IEC 61482-1-1 , IEC 61482 1-2**
 - Fabrics
 - Garments
- **ASTM F 2178**
 - Face Shields
- **ASTM F 2675**
 - Hand Protection (gloves)
- **ASTM F 1891 and ASTM F 2733**
 - Rainwear

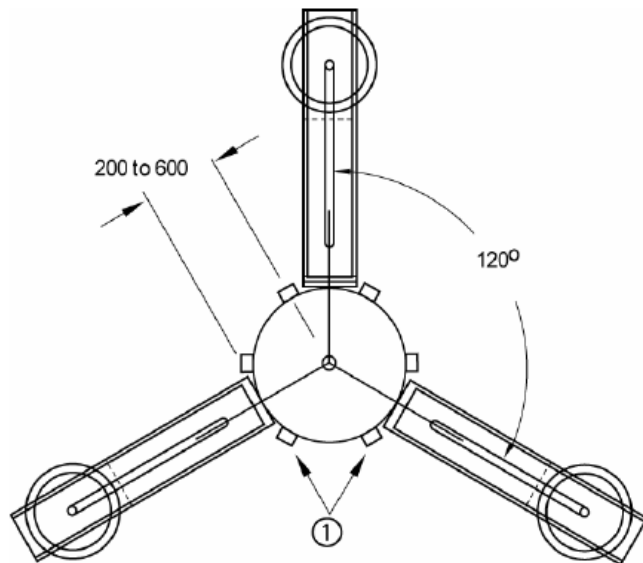
PROJECT TECHNICAL DEVELOPMENT

- Mechanical Drawings

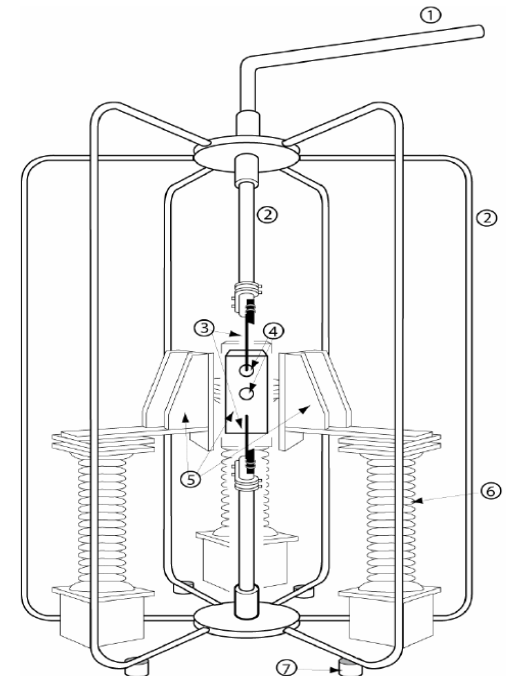


PROJECT TECHNICAL DEVELOPMENT

•Test Apparatus - Fabrics



IEC 801/09



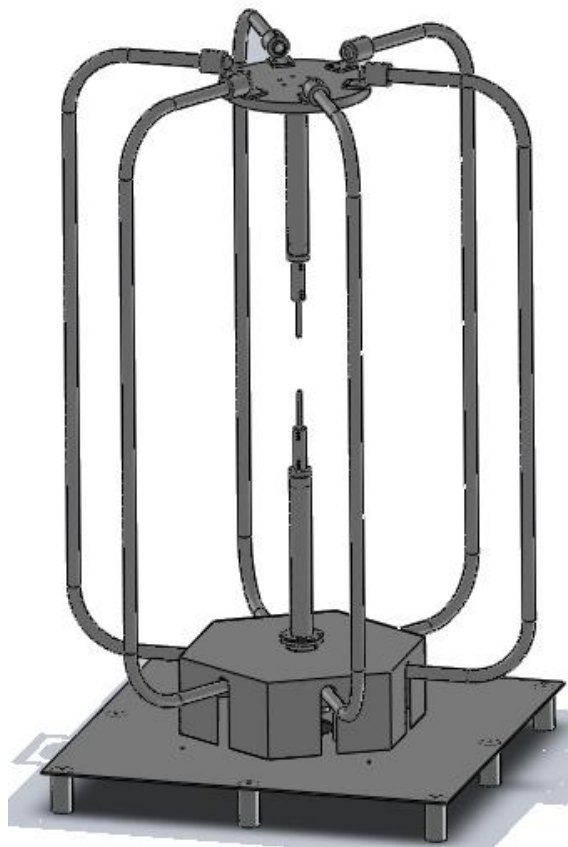
IEC 811/09

Key

- | | | | |
|---|--------------------|---|------------------|
| 1 | Coaxial bus supply | 5 | Panel |
| 2 | Bus | 6 | Insulating stand |
| 3 | Electrode | 7 | Insulator |
| 4 | Sensor | | |

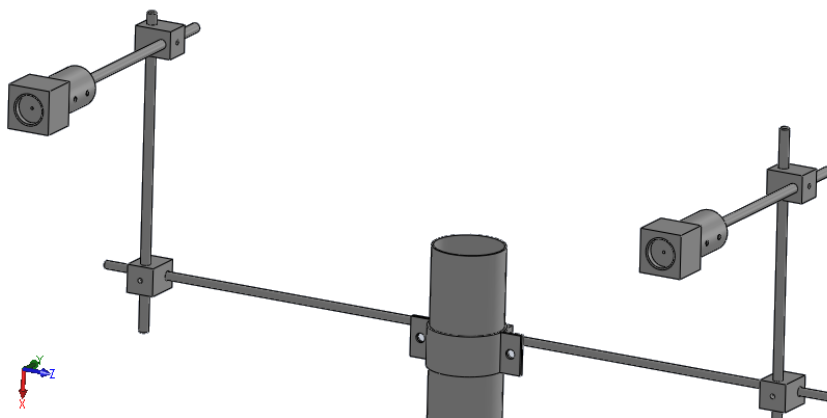
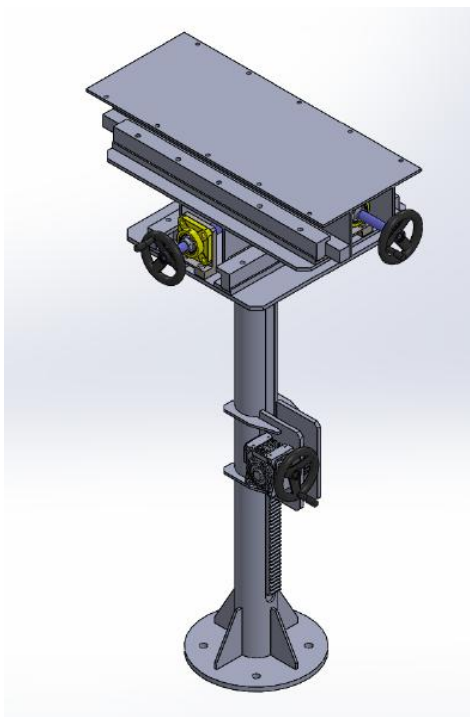
PROJECT TECHNICAL DEVELOPMENT

- Arc Flash Bus



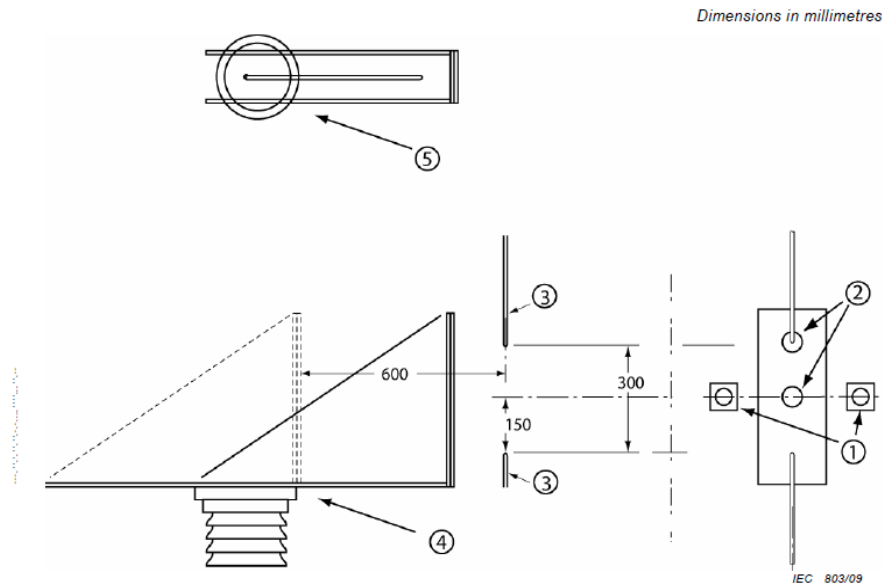
PROJECT TECHNICAL DEVELOPMENT

- Support and external calorimeters



PROJECT TECHNICAL DEVELOPMENT

•Test apparatus: Panel Details - Fabrics



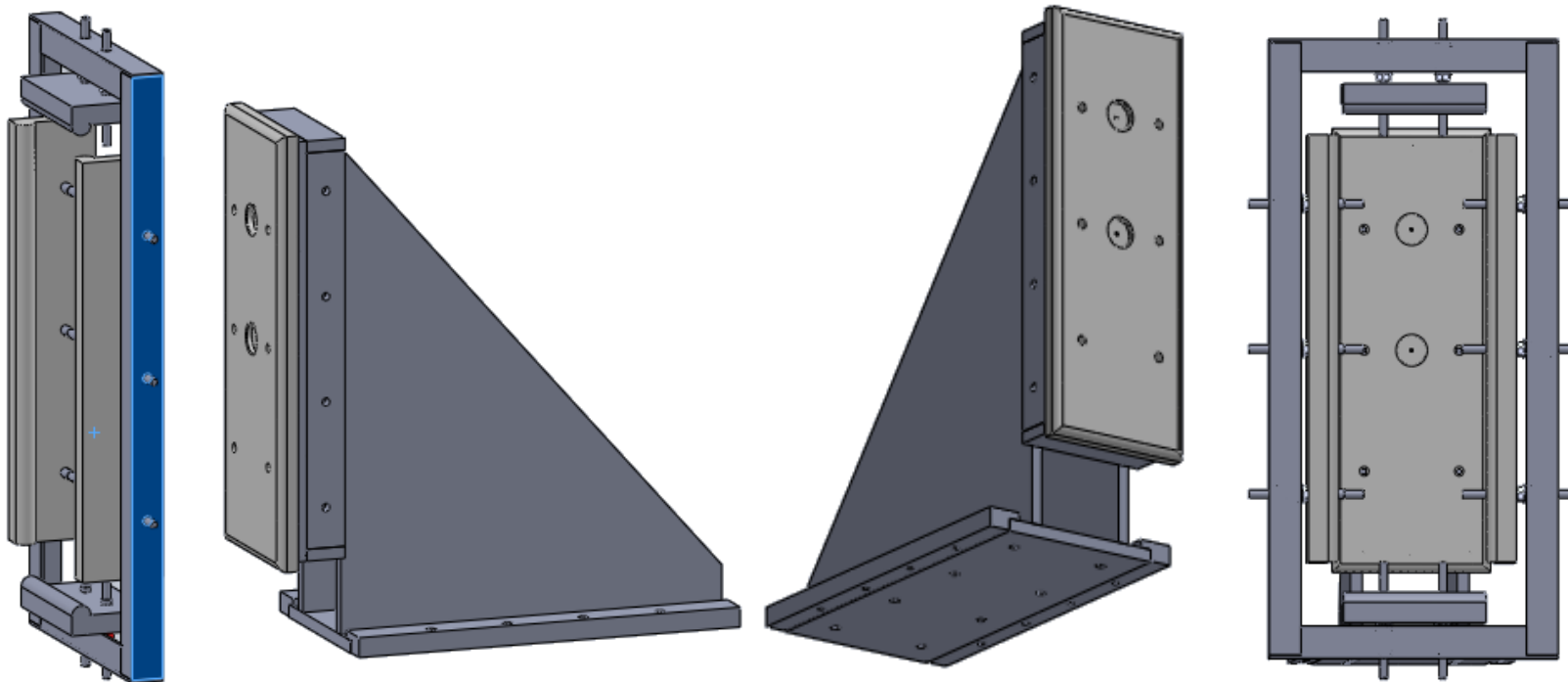
Key

- | | | | |
|---|---|---|--|
| 1 | Monitoring sensor | 3 | Electrode |
| 2 | Sensor | 4 | Movable two-sensor panel mounted in insulating stand |
| 5 | Slide system provided by user shall include method to maintain alignment and locking device | | |

PROJECT TECHNICAL DEVELOPMENT

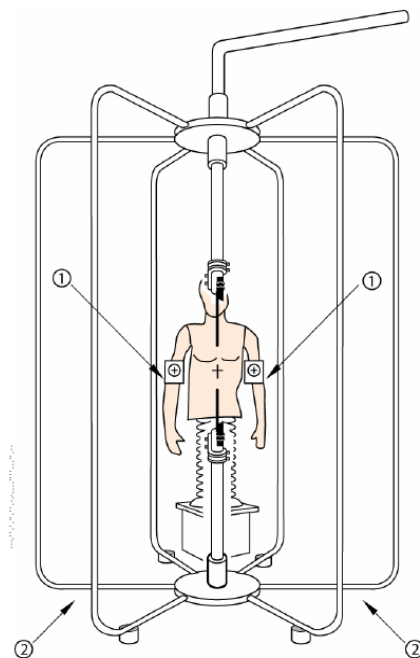
•Test apparatus:

Panel Details - Fabrics



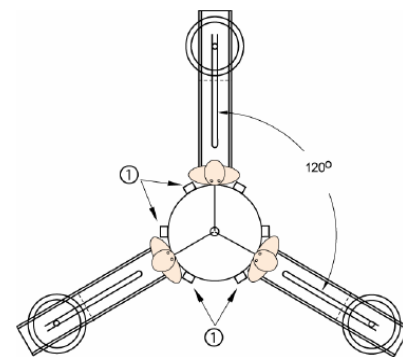
PROJECT TECHNICAL DEVELOPMENT

- Test apparatus
 - Garments
 - Face Shields



IEC 804/09

Front view

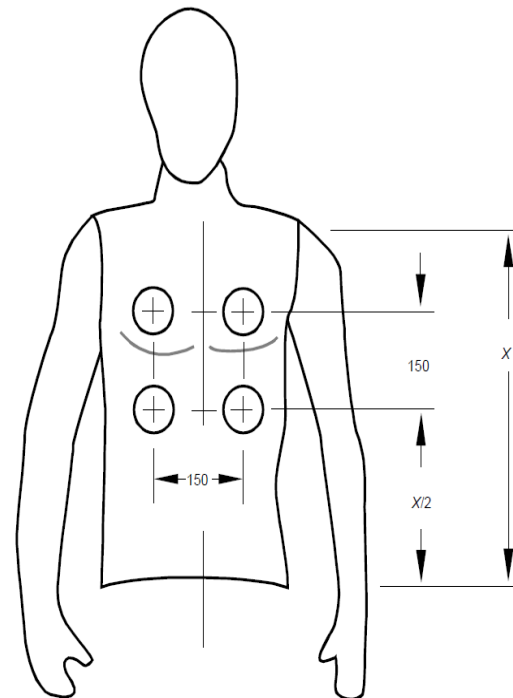
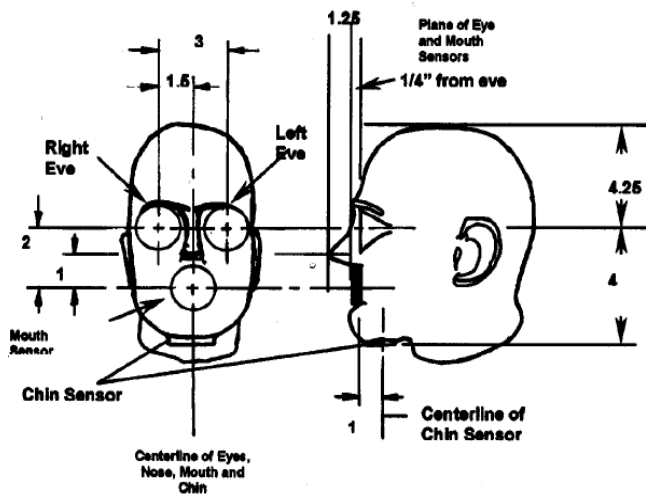


IEC 805/09

Top view

PROJECT TECHNICAL DEVELOPMENT

- Test apparatus
 - Garments
 - Face Shields



IEC 524/02

Dimensions in millimetres

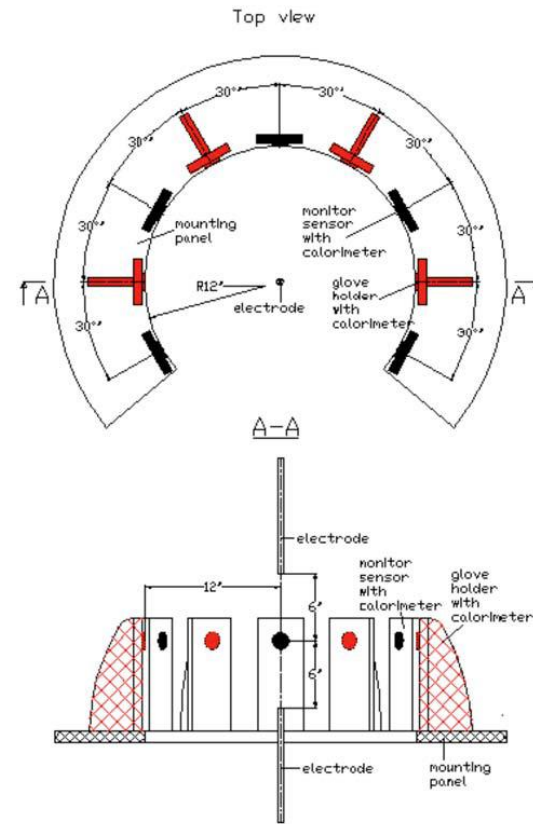
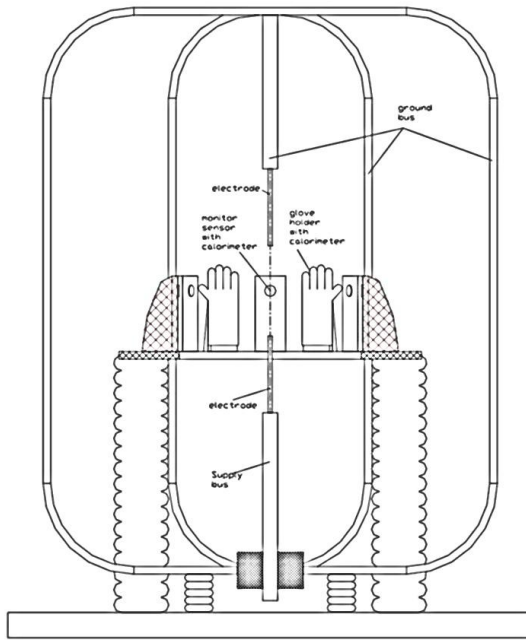
PROJECT TECHNICAL DEVELOPMENT

- **Test apparatus**
 - **Garments**
 - **Face Shields**



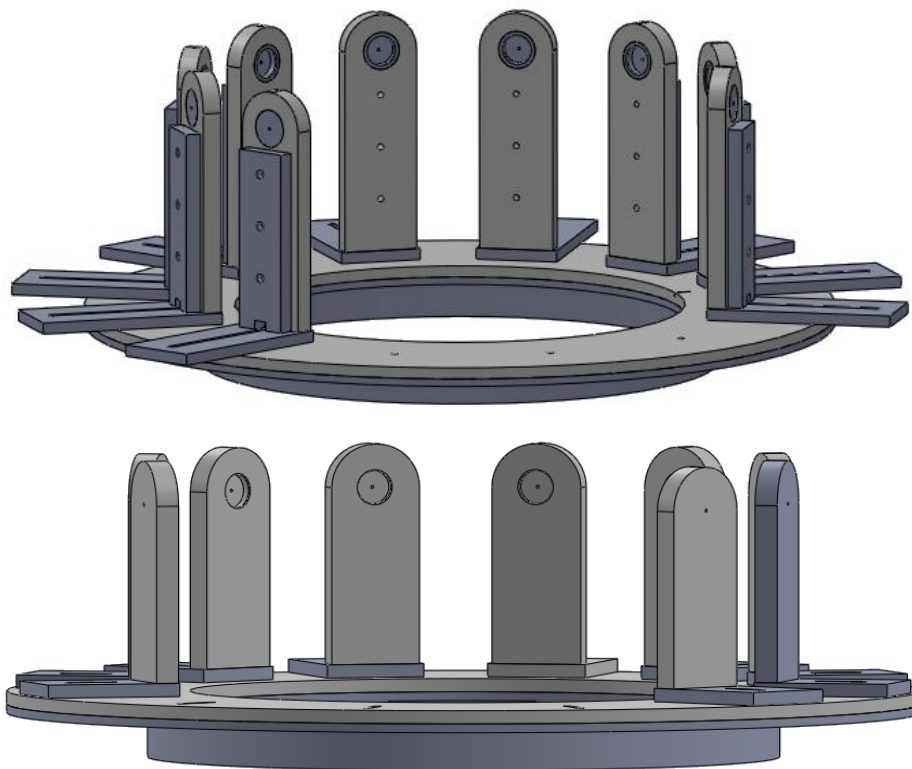
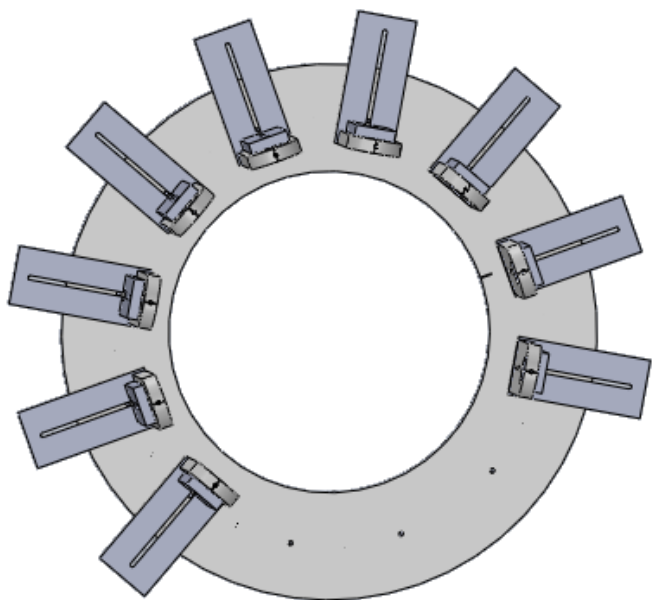
PROJECT TECHNICAL DEVELOPMENT

- Test apparatus
- Gloves



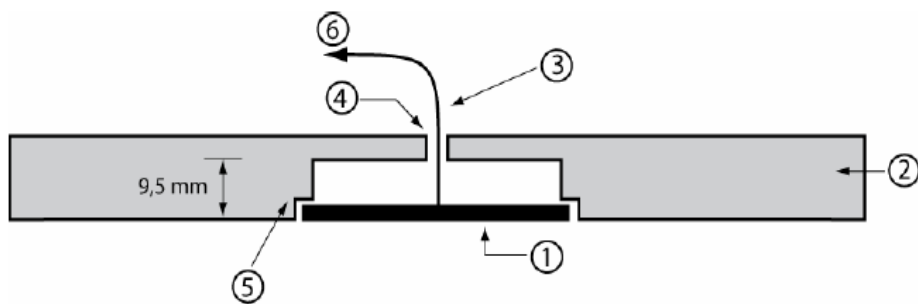
PROJECT TECHNICAL DEVELOPMENT

- Test apparatus
- Gloves



PROJECT TECHNICAL DEVELOPMENT

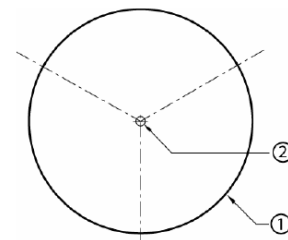
•Calorimetric Sensors



IEC 810/09

Key

- | | | | |
|---|---|---|----------------------------|
| 1 | Electrical grade copper disk of 18 g , Ø 40 mm, 1,6 mm thick, (pinned in place) | 4 | Hole of 3,2 mm diameter |
| 2 | Insulation board, minimum thickness ~1,3 cm | 5 | Ledge, 1,6 mm × 1,6 mm |
| 3 | Type K (NiCr - NiAl) or Type J (Fe - CuNi) thermocouple | 6 | Signal to data acquisition |



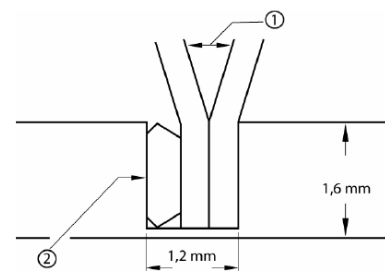
IEC 808/09

Sensor of electrical grade copper, of 40 mm diameter

Thermocouple location

The central hole shall have a diameter of 1,2 mm and a depth of 1,3 mm.

Figure 7a – Installation of the thermocouple in the calorimeter



IEC 809/09

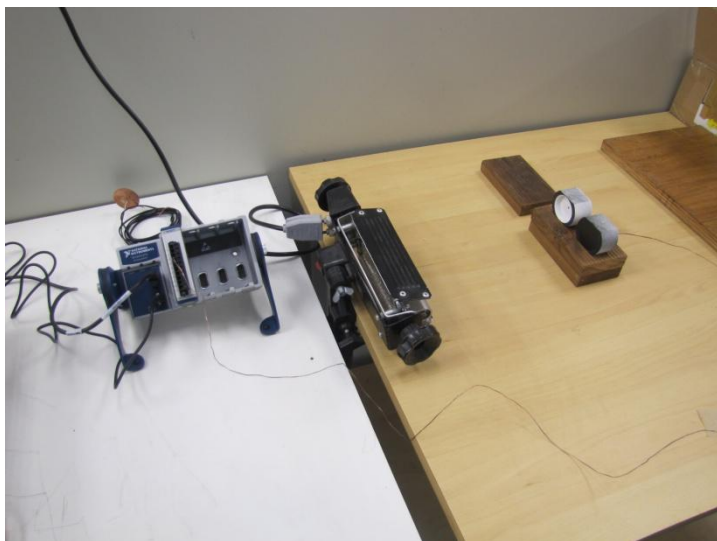
Separate thermocouple wires

Position a thermocouple with total outer diameter of 0,254 mm. The plug shall be pressed into the hole such as to fill it up completely. The separation point of the thermocouple wires shall be at the surface of the copper disk, as shown in the drawing.

Figure 7b – Thermocouple wire installation – Hole detail and method of securing thermocouple

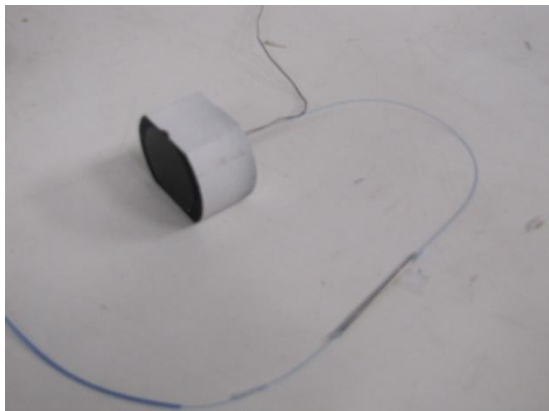
PROJECT TECHNICAL DEVELOPMENT

•Calorimetric Sensors



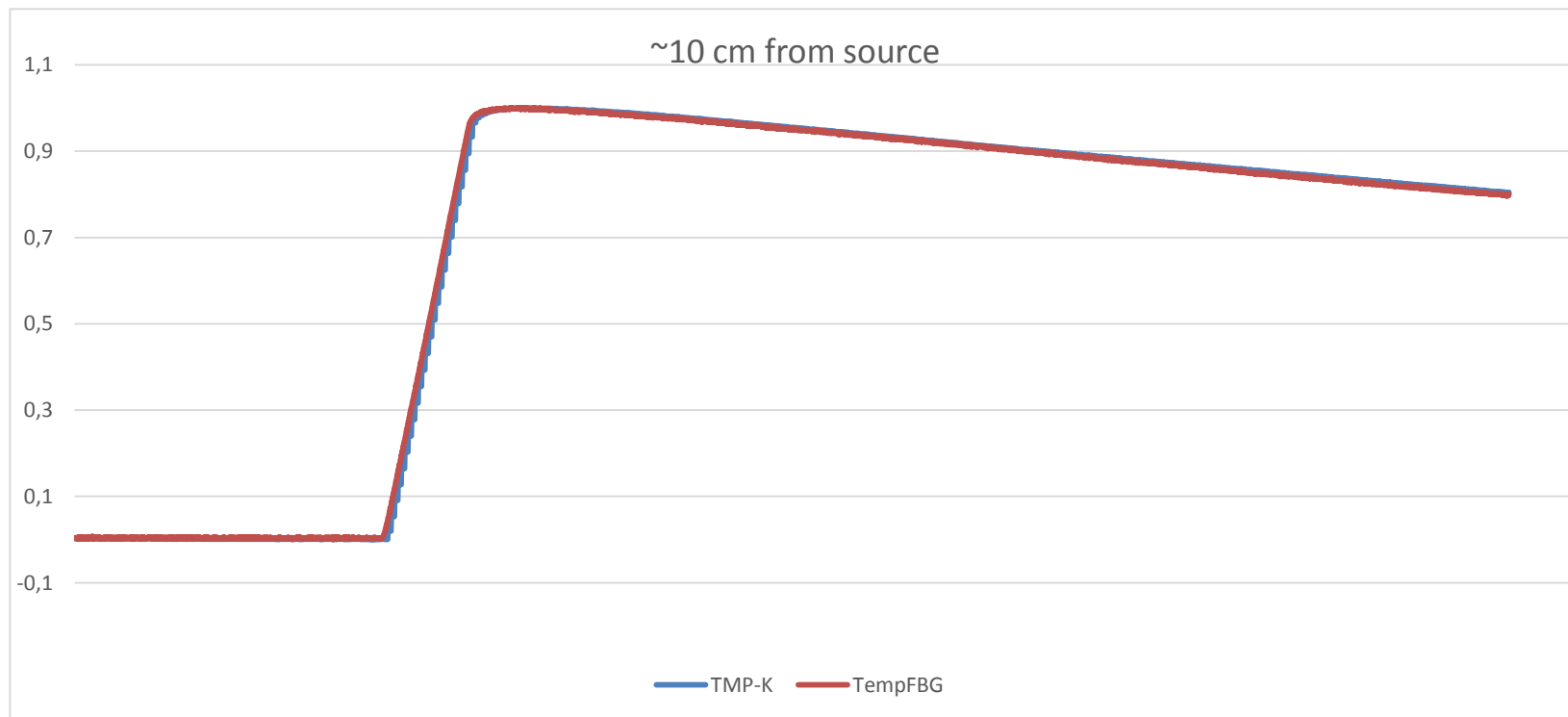
PROJECT TECHNICAL DEVELOPMENT

- Calorimetric Sensors – New Sensor purposes
- Fiber Bragg Grating



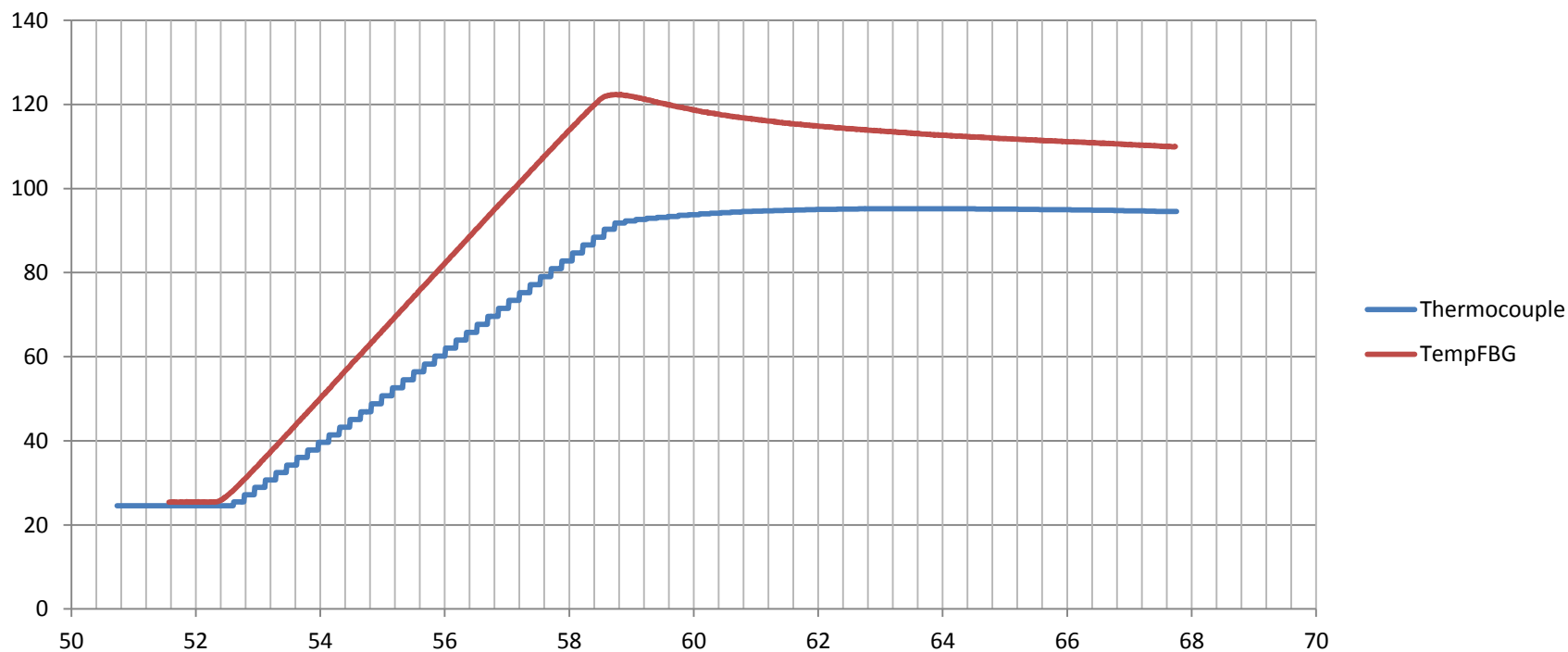
PROJECT TECHNICAL DEVELOPMENT

•FBG – First Results



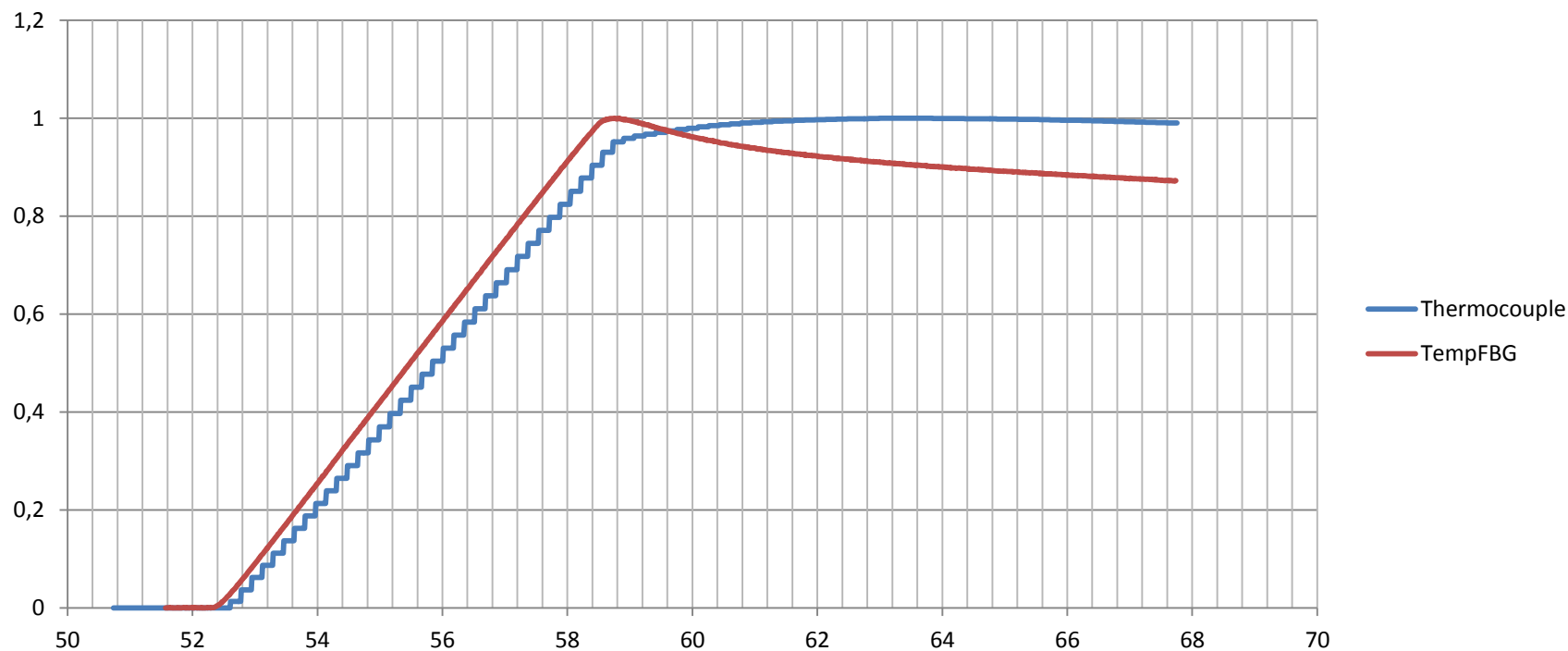
PROJECT TECHNICAL DEVELOPMENT

•FBG – First Results



PROJECT TECHNICAL DEVELOPMENT

•FBG – First Results



PROJECT TECHNICAL DEVELOPMENT

•FBG – Advantages

- Electromagnetic Immunity
- Sensor distances (thermocouple limited up to 30 m)
- Multiple sensor in the same fiber bus (flash fire too)
- Time response – under evaluation
- Corrosion and water resistant

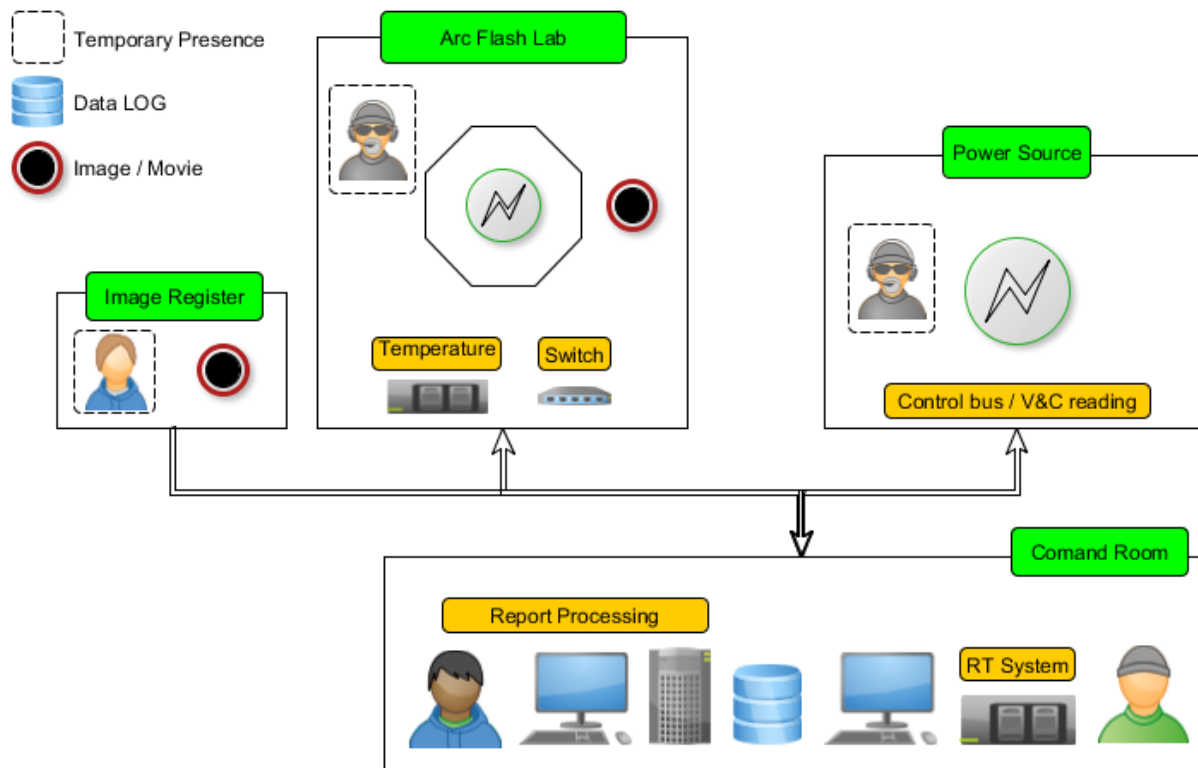
•FBG – Disadvantages

- Mechanical strength
- Cost



PROJECT TECHNICAL DEVELOPMENT

•Arc Flash Control and Measurement System



PROJECT TECHNICAL DEVELOPMENT

- Real Time/FPGA Control and Measuring System



PROJECT TECHNICAL DEVELOPMENT

- Image and Movie registering process



PROJECT TECHNICAL DEVELOPMENT

- **Automatic report process**
 - **Project System: Under Development. Objective is to be integrated with Control and Measuring System used during tests to allow reports to be available in the same day of tests.**

PROJECT TECHNICAL DEVELOPMENT

- **Evaluation Software**

- All data processing is established by American and International Standards
- Calculations are based on temperature to Energy Conversion and Comparisons with Stoll Curve
- Requirement: Perform ATPV, EBT, HAF

LABORATORY ISSUES

- **Tests for Fabrics and Garments – Brazilian Regulations and investigation processes;**

LABORATORY ISSUES

- **Development and research – New products, new areas, Test enhancement and development (IEC / CB32);**