MONITORING OF COMPONENTS DURING OPERATION USING THE POTENTIAL DROP METHOD

Petr Živný

Research Centre Řež (CVŘ) Czech Republic

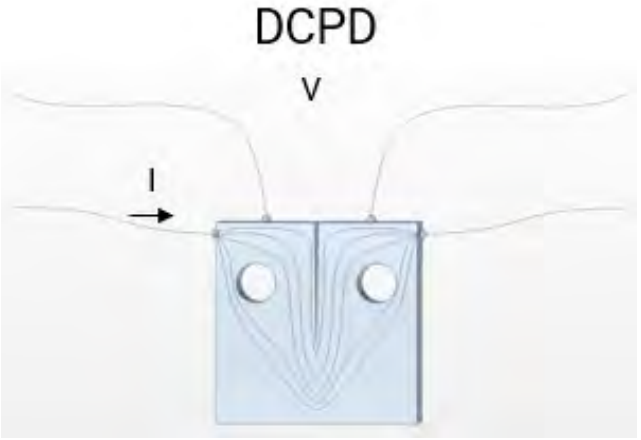
CORE conference

November 20, 2025

Basic Description of the Method

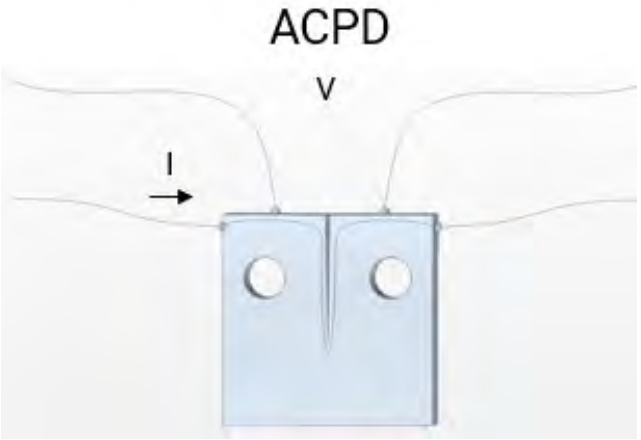
Principle of Defect Detection

Defects change current pathways, causing measurable voltage changes, enabling non-destructive evaluation of materials



According to the type of supply current, potential drop methods are divided into:

- **Alternating Current Potential Drop Method (ACPD)**
- **Direct Current Potential Drop Method (DCPD)**



Application Considerations

Choosing ACPD or DCPD depends on application needs, material properties, and environmental conditions

Use of the Potential Drop Method

The potential drop method enables:

- Detection and monitoring of crack growth
- Measurement of wall thickness
- Measurement of corrosion losses
- Monitoring of material changes

Applications:

- In material laboratories, it is used to determine defect size
- In industry, for monitoring critical parts of selected components

Industrial Implementation:

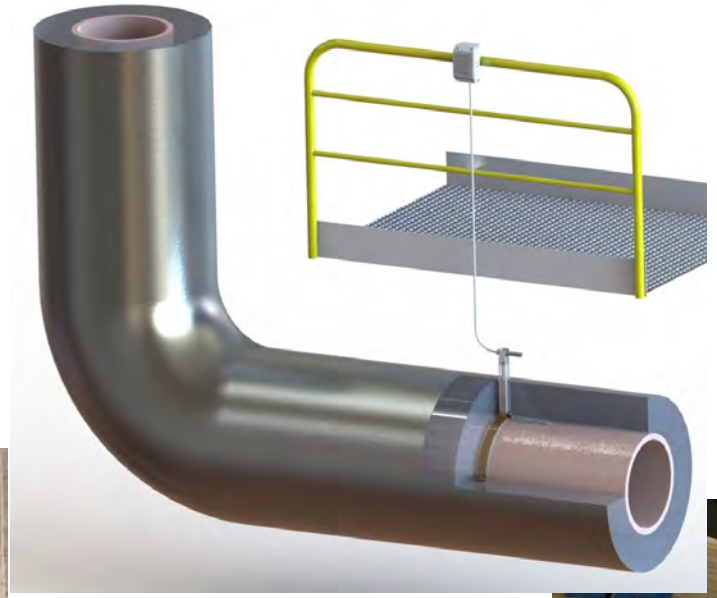
- Power industry, construction, chemical and other industries
- Ensuring safe operation, minimizing costs, and estimating the remaining service life of equipment

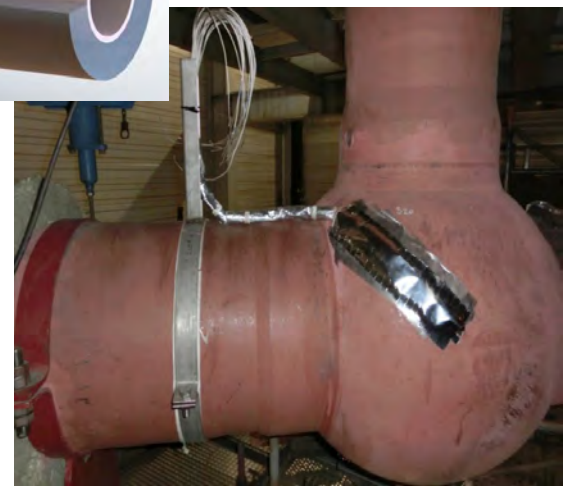
Current Use of the Potential Drop Method

Current Application – Thermal power plants; several years of experience

Extreme Environment

- High temperature (550 °C) and pressure up to 15 MPa
- Applicable in radioactive environments
- Long-term installations (inaccessible areas, under insulation)





Development Projects

Off-line System – Research and Development Project

Project Name: DROPOT

Subject: Development of a mobile version of a functional device

Client: ČEZ, a.s.

Supplier: CVŘ s.r.o.

Project implementation period: 01/2024 – 06/2025

Project scope: Production of a functional prototype of a mobile measuring device

The developed device will be intended for identifying and monitoring crack growth in critical parts of steam pipelines. The goal is to optimize the measuring system for higher sensitivity to the initiation and growth of material defects. The new measuring system should replace the old equipment Poteron PD 05.

Development Projects

On- line System – Research and Development Project

Project Name: POTMET

Subject: Development of an online version of a functional remote monitoring device

Project program: Internal project within Institutional Support

Principal investigator of the project: CVŘ s.r.o.Supplier: CVŘ s.r.o.

Project implementation period: 01/2023 – 12/2027

Project scope: development of a new online measuring device, creation of database software, preparation of test specimens, testing and calculations for method optimization

The project should contribute to increasing the safety of operating power units of conventional (thermal), hydro and nuclear power plants.

DROPOT – Evaluated parameters

Typical configuration on a single pipe weld

- Up to 8 channels
- Four-electrode configuration consisting of two excitation and two measuring electrodes per channel

Measured quantities

- Voltages
- Currents
- Temperature

Example of data post processing

- Elimination of DC offset
- Resistance of channel
- Elimination the dependence on temperature (resistence relative to average)

DROPOT – experimental tests on „prisms“

Objective: Comparison of DCPD measurements on real cracks with simulated defects.

1. Tests on samples with real cracks

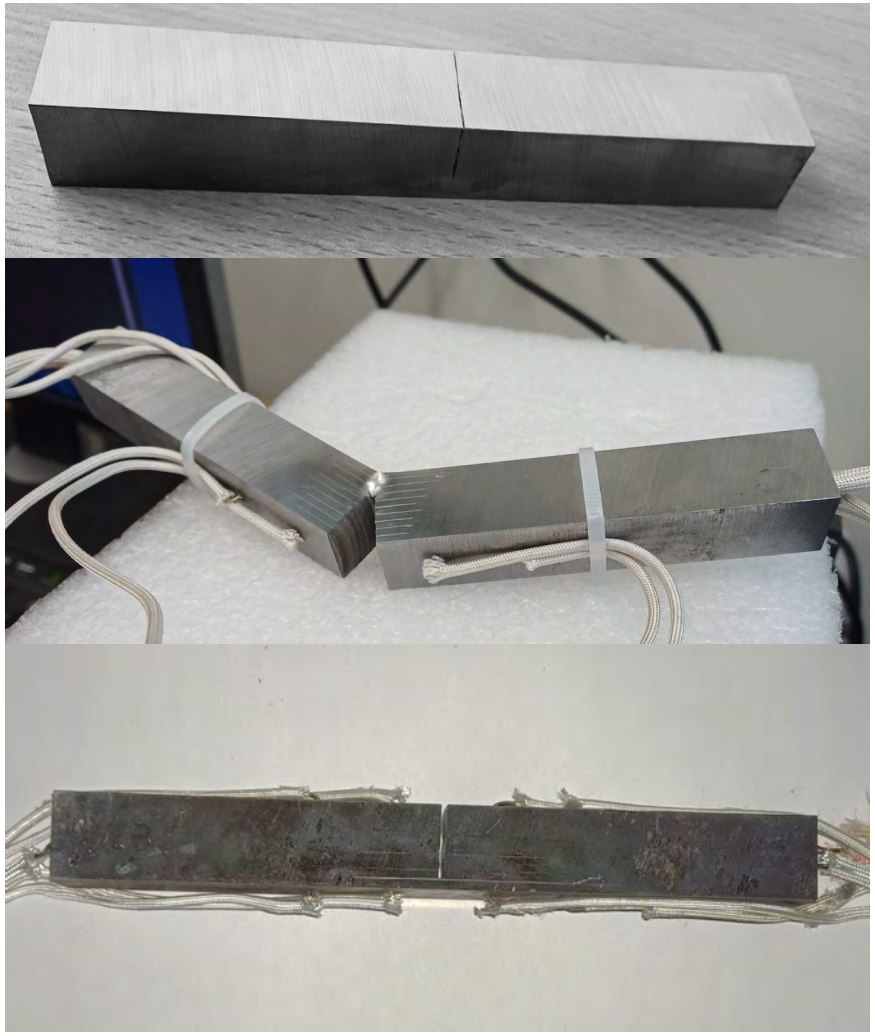
- The objective of the test was to create the most realistic crack

2. Tests on samples with created defect using electrical discharge machining

- The objective of the test was to create a defect of defined dimensions.

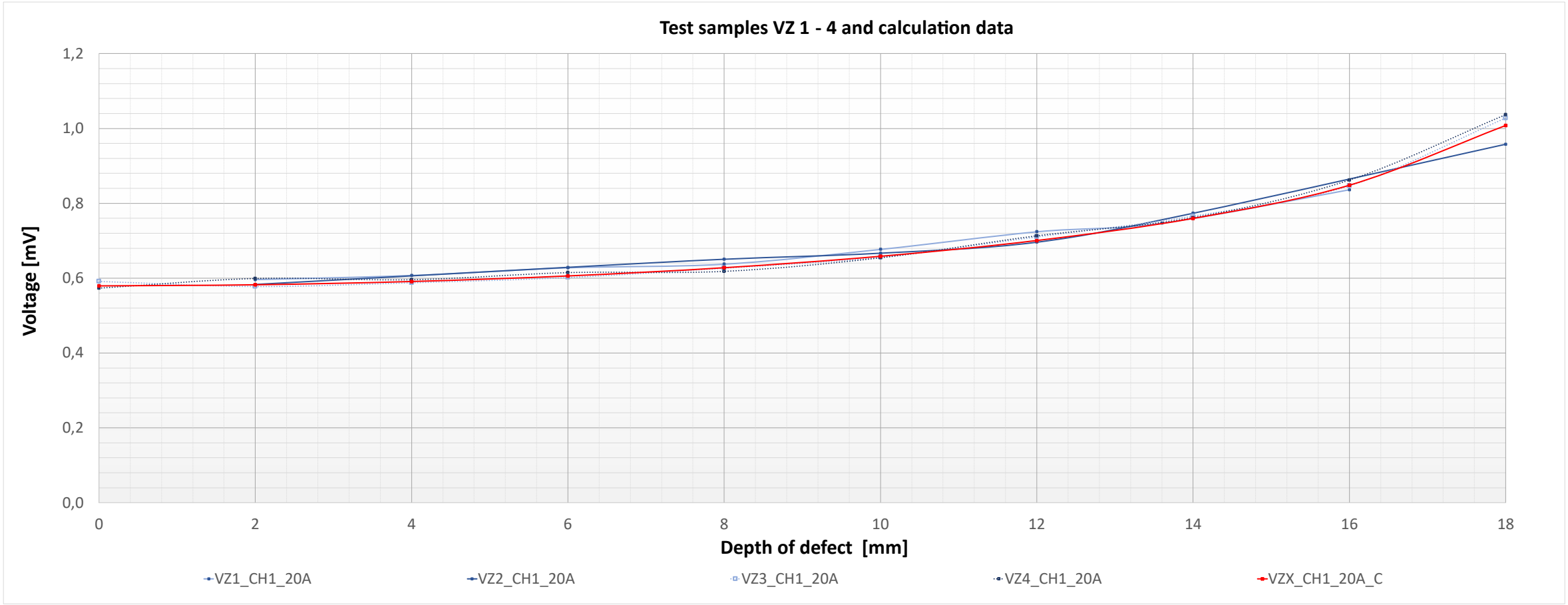
3. Tests of samples with an artificially created defect by chip machining

- The objective of the test was to create a defect of defined dimensions, which would allow to assess the influence of the defect production method and thermal stress.



Test specimen dimensions: 20x20x200 mm

DROPOT –Test evaluation

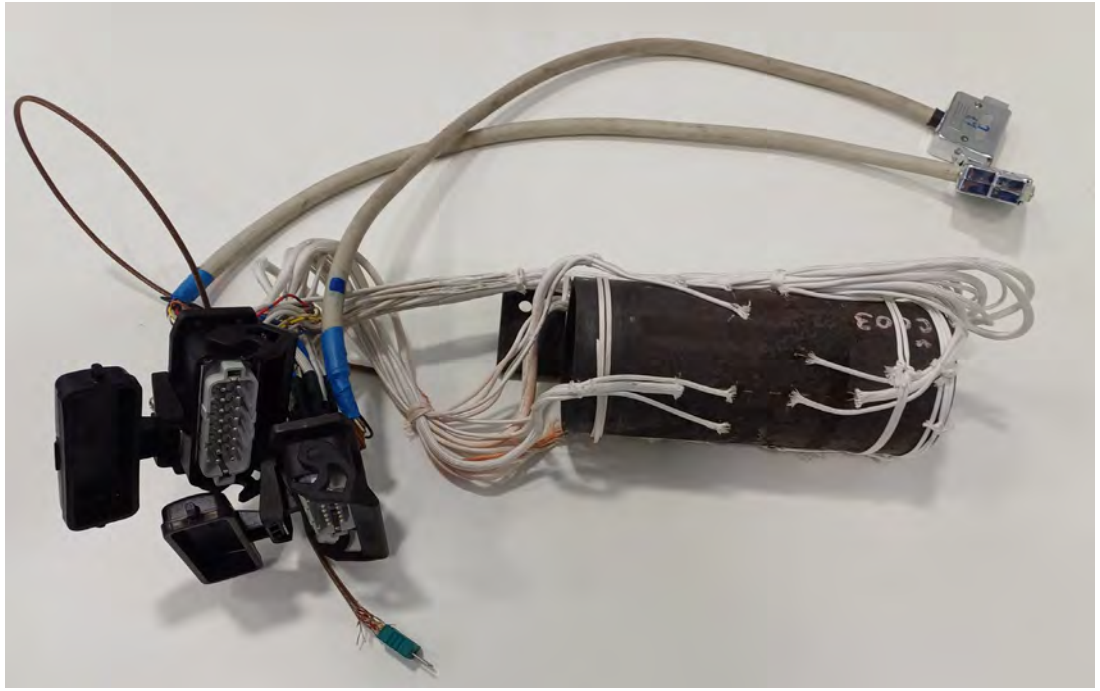


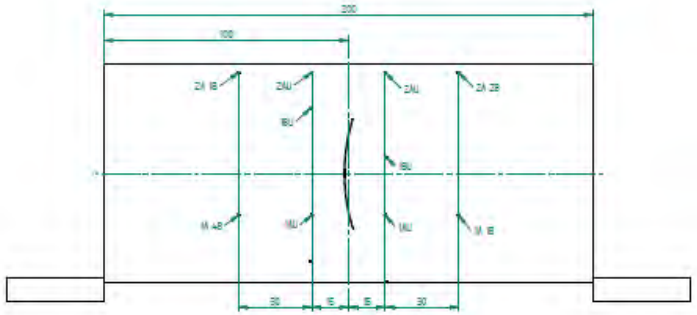
Results from potential measurements on individual test specimens with increasing defect including calculated values

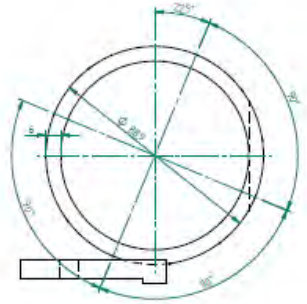
DROPOT – Experimental tests on „pipes“

Pipe ø 89 mm, wall thickness 5.9 mm,

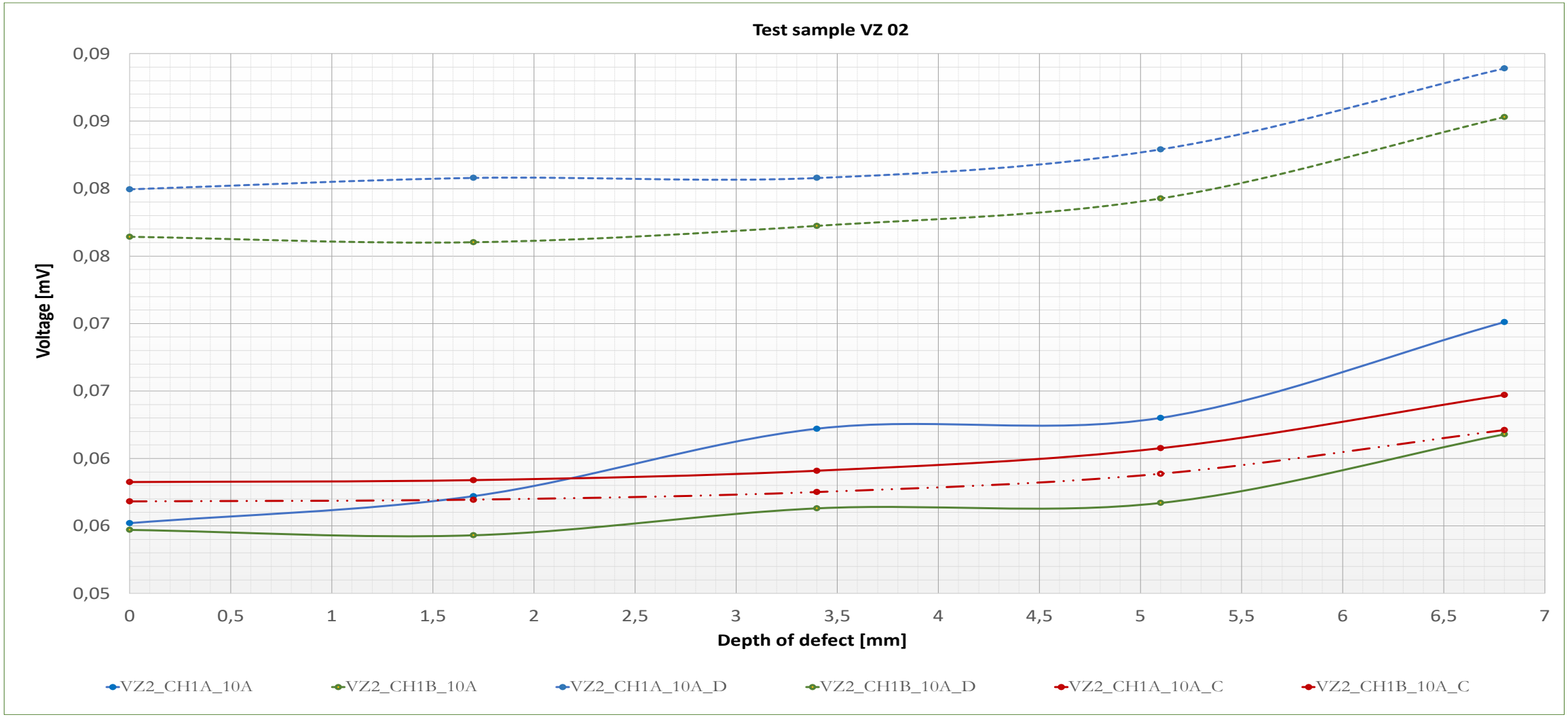
material carbon steel 12022.1





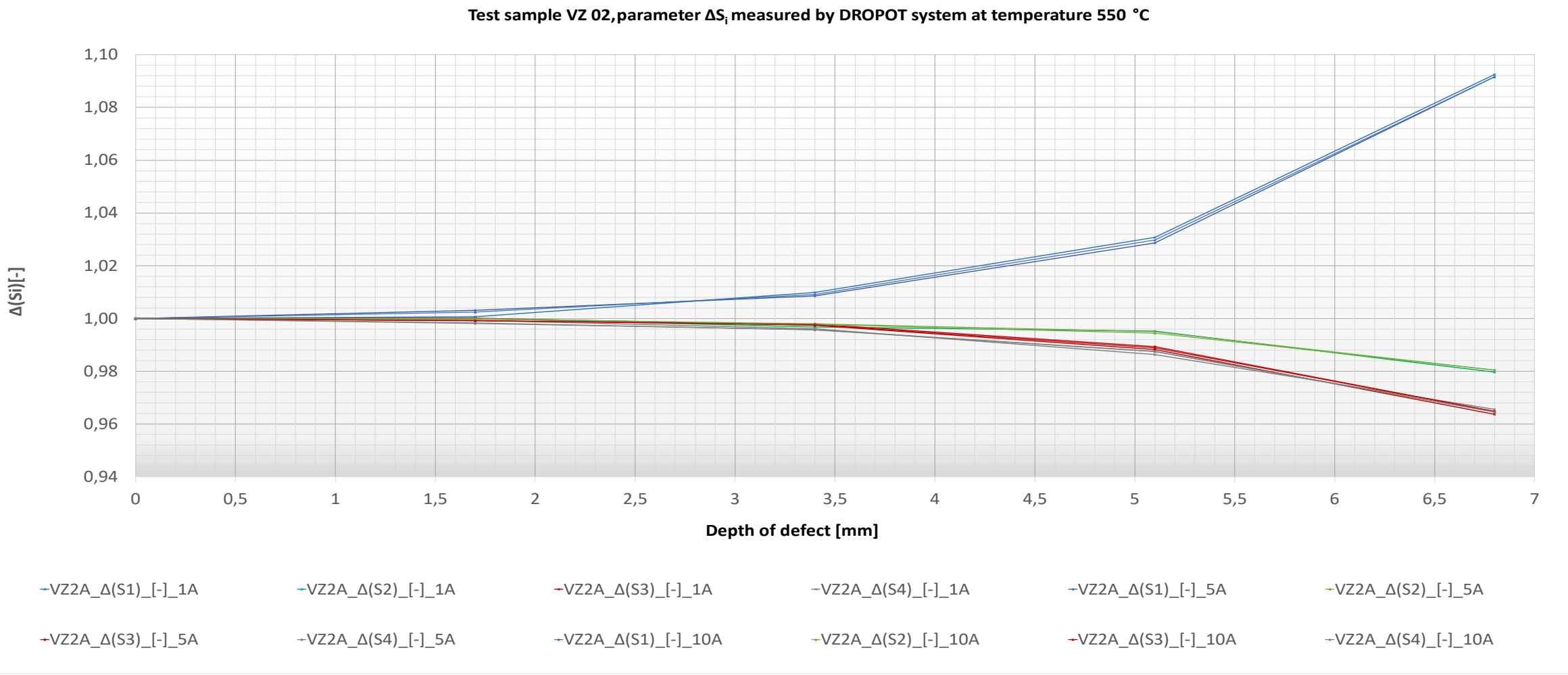


DROPOT –Test evaluation



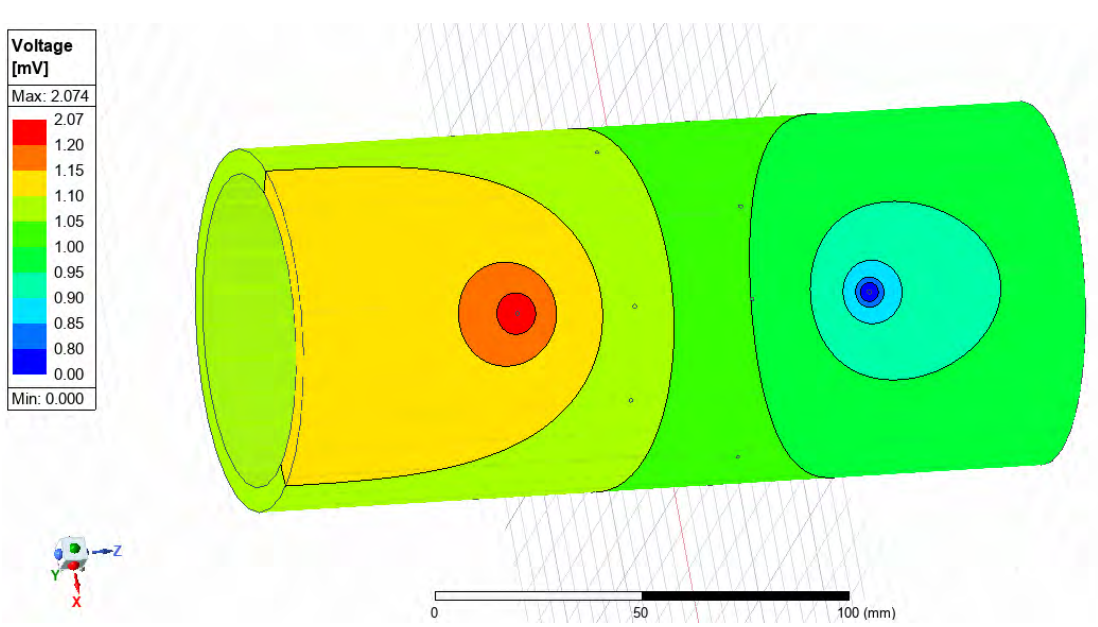
Results from **U_x potential measurements** with increasing defect depth for different current sources

DROPOT –Test evaluation

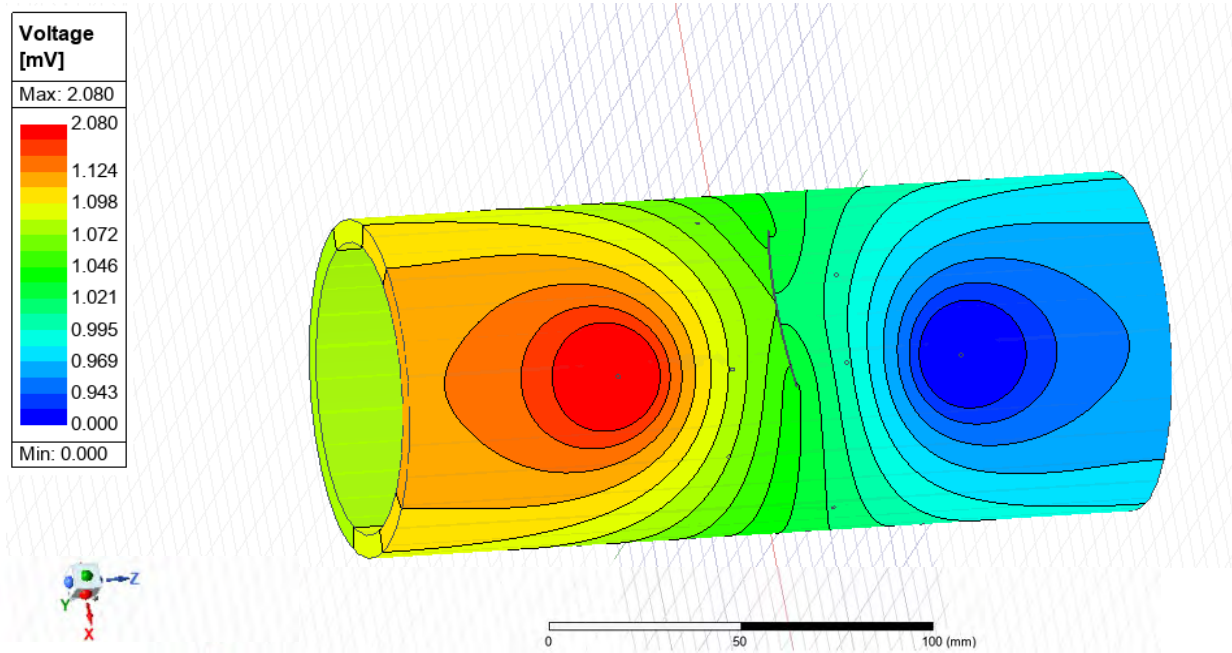


Results from **S_i parameter** measurement with increasing defect

Numerical calculations and field modelling

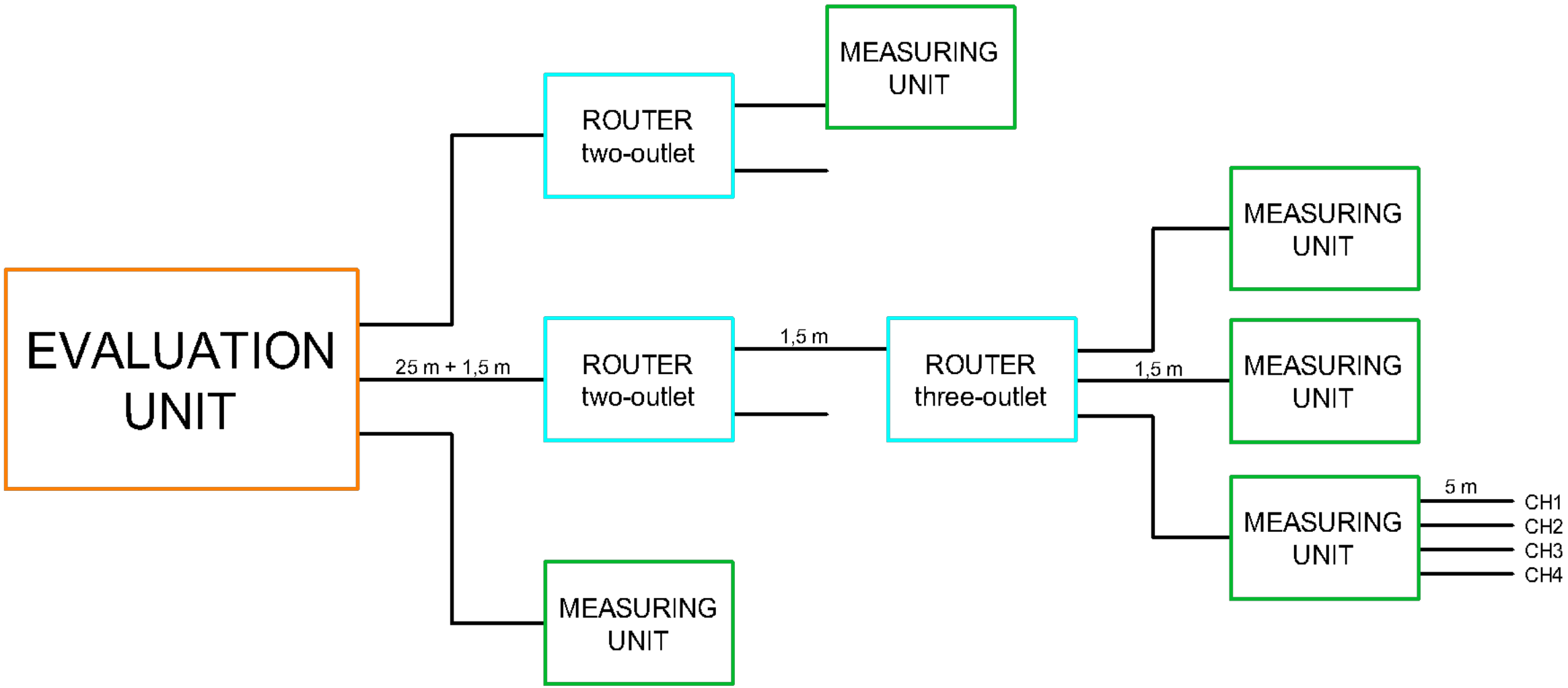


Without defect



With defect

DROPOT – description



Connection diagram

DROPOT – description

Measuring unit 6 includes:

- 1 piece of 1.5 m power and communication cable with connector
- 4 pieces of 5 m connecting cables for measuring resistance on four measuring channels (each measuring channel is four-wire) with an excitation current of up to 20 A
- The measuring unit also includes 1 piece of 5 m cable for connecting a thermocouple

DROPOT – description

The monitoring system is stored in three aluminum cases.

The two larger cases contain six measuring units, four routers and one 25-meter extension cable.

The smaller „evaluation“ case contains:

- **Evaluation unit**, which contains the Raspberry Pi computer with evaluation software
- Power is supplied using a $LiFePO_4$ **battery pack** with parameters of 48V / 16 Ah

The DROPOT device also includes **2 verification shunts** (2.5 mΩ and 0.1 mΩ) including calibration sheets

DROPOT – description

The **4 routers** are used to connect up to 24 measuring channels (6 measuring units x 4 measuring channels) at the same time to the evaluation unit:

- **3 pieces of two-outlet routers** with 1.5 m cable each for connecting to 2 pieces of measuring units
- **1 piece of three-outlet router** with 1.5 m cable for connecting to 3 pieces of two-outlet routers

Conclusions

- The developed system uses the DCPD technique for offline crack monitoring up to 550 °C
- The sensitivity of the system has been verified by laboratory tests, the detectability of cracks depends on the actual pipe wall thickness

EPRI evaluated the potential method as one of the methods for monitoring components of new generation reactors

Issues that need to be addressed within the framework of research and development activities:

- Electrodes placement
- Welding method optimization
- Impact of measurement system connection loss
- The effect of disturbing operating voltages on the measured parameters

By using new high-quality electronic components, the potential drop method has great potential!

Thank you for your attention

petr.zivny@cvrez.cz