Supplement of Saf. Nucl. Waste Disposal, 1, 291–292, 2021
https://doi.org/10.5194/sand-1-291-2021-supplement

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Safety of Nuclear Waste Disposal
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Supplement of

Issues of long-term durability of paper – Labest Papier

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Interdisziplinäres Forschungssymposium für die Sicherheit der nuklearen Entsorgung

Issues of long-term durability of paper – Labest Papier

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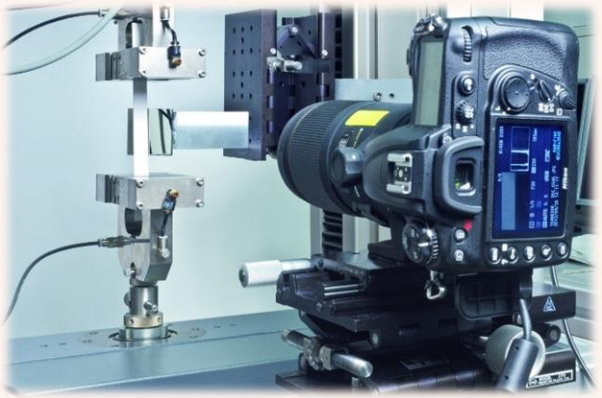
Technical University of Darmstadt – Chair of Paper Science and Mechanical Engineering (PMV)

PMV

Technical University of Darmstadt – Fachgebiet Papierfabrikation und Mechanische Verfahrenstechnik (PMV)

- founded 1905
- 24 employees
- interdisciplinary cooperation
- international networking
- four main research areas
- research partner and flexible service provider



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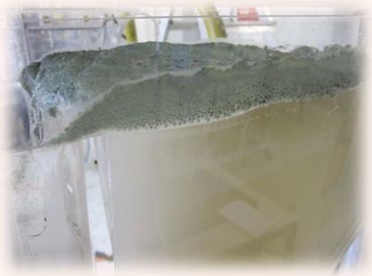
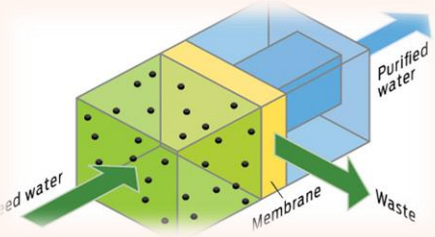
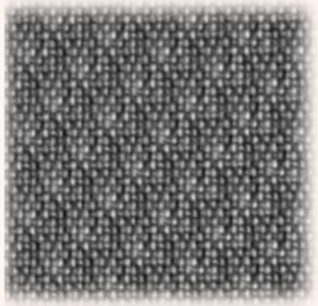
Recycling





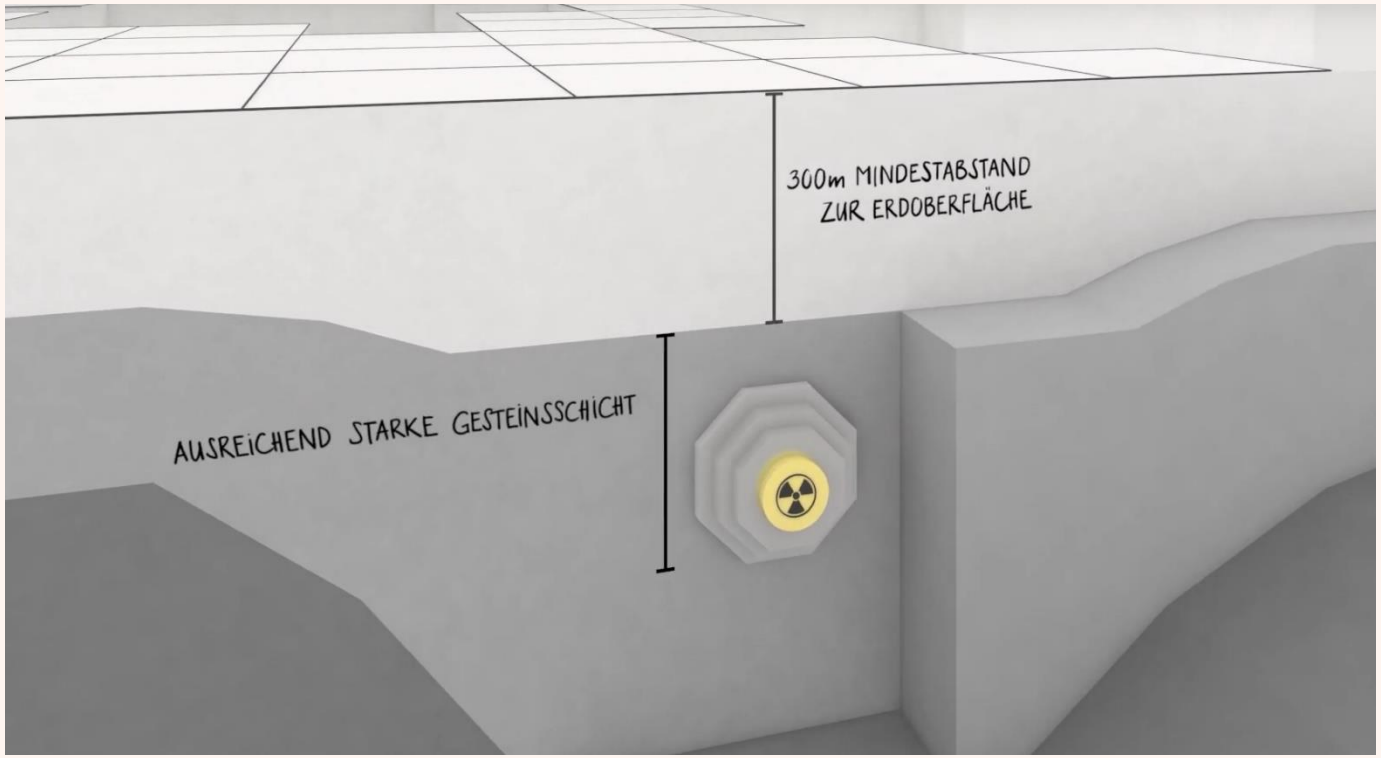
Environment and Consumer Protection

Paper Physics and Metrology



Innovative, fibre-based Products

Labest Papier – Langzeitbeständigkeit von Papier
long-term durability of paper



Project launched and financed by the German Federal Authority for the Disposal of Nuclear Waste

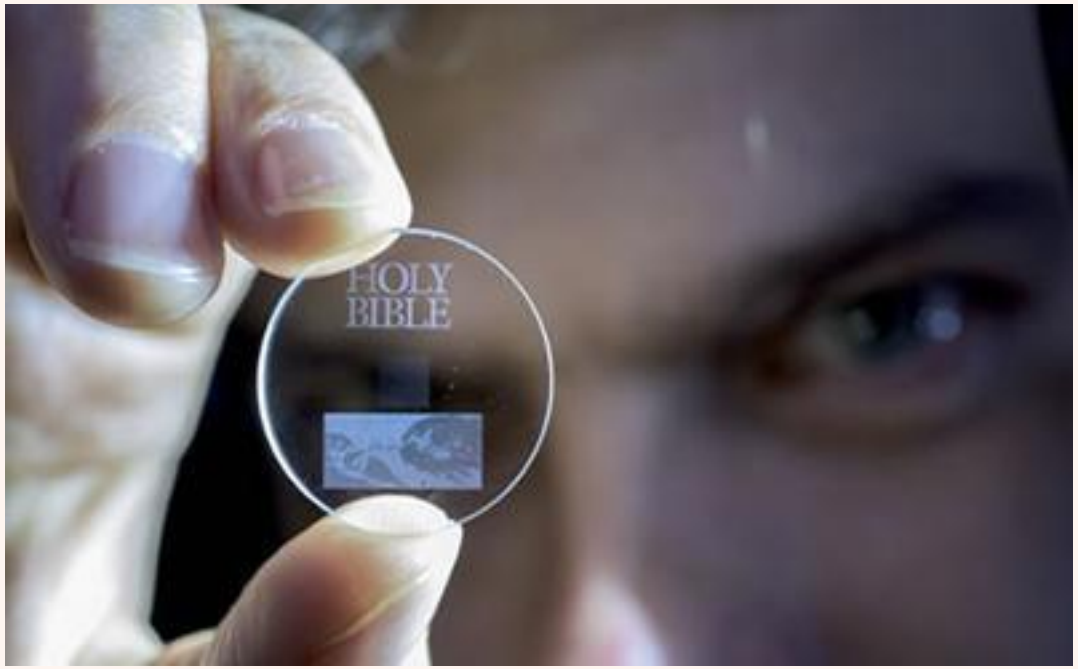
-

Bundesamt für die Sicherheit der nuklearen Entsorgung (BASE)

Labest Papier – background

- civil-nuclear waste since approximately 1960 needs a final repository
- information and documentation must still be available for at least 500 years, respectively as long as technically necessary
- archives rely on a triad
  paper – digitalisation – microfilm
- new ideas are
  DNA, the genetic material
  and
  quartz, a nanostructured glass

Data archiving – quartz glass



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“Superman Memory Crystal”

Using nanostructured glass, scientists from the University of Southampton have developed the recording and retrieval processes of five dimensional (5D) digital data by femtosecond laser writing.

As a very stable and safe form of portable memory (virtually unlimited lifetime at room temperature), the technology could be highly useful for organizations with big archives.

Impressive – up to 1,000 °C thermal stability, high data capacity.

- **Needs sophisticated equipment and knowledge**

Data archiving - DNA

LOEWE-Emphasis MOSLA, University of Marburg

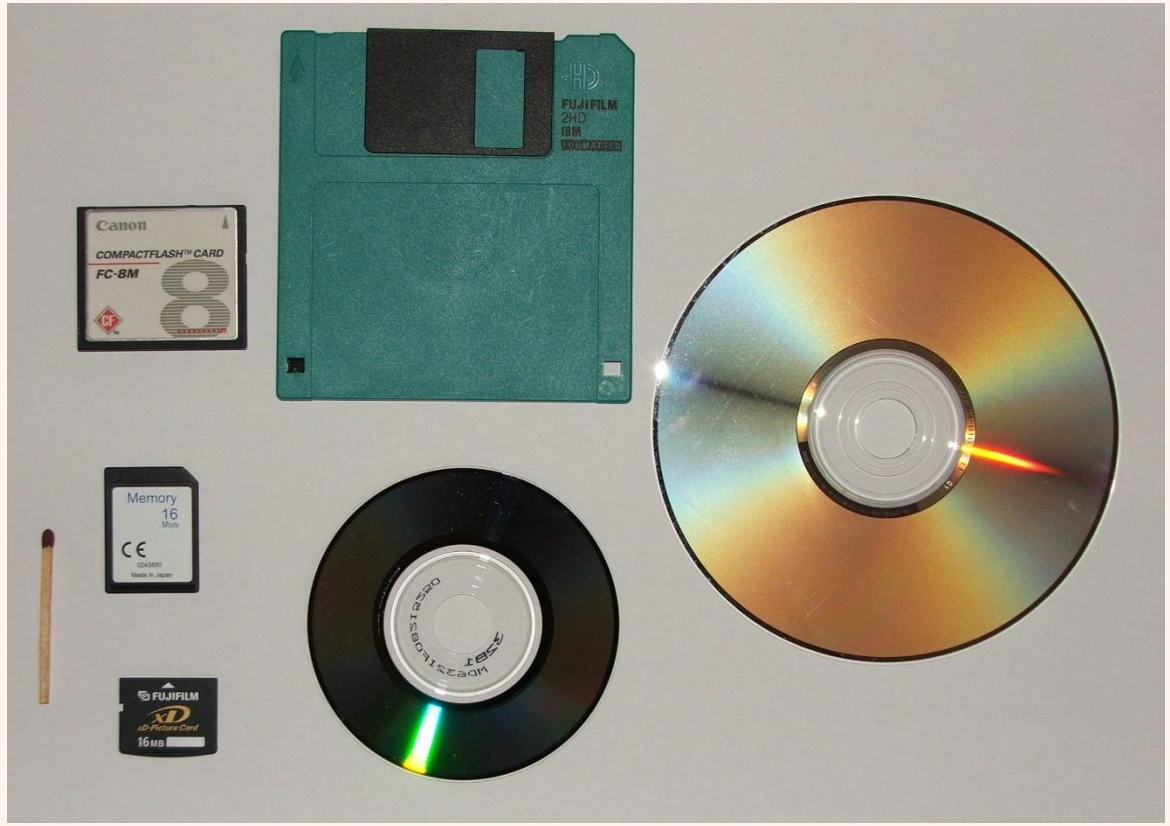
Research project MOSLA (Molecular storage for long-term archiving) develops trans-disciplinary approaches to the solution for one of mankind's fundamental problems: the long-term storage of information.

The four acids Guanin, Thymin, Cytosin and Adenin are related to 10, 11, 01 and 00. An algorithm transfers data into DNA-segments, easy to duplicate. Protected with glass, durability is estimated to be 1,000 years.

Extraordinary high memory capacity – all the actual knowledge of mankind needs about 1.5 kg DNA only.

- **Needs sophisticated equipment and knowledge**

Data archiving – digital recording



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DIN 31644 to 31647 & ISO 13008:
Digital recording

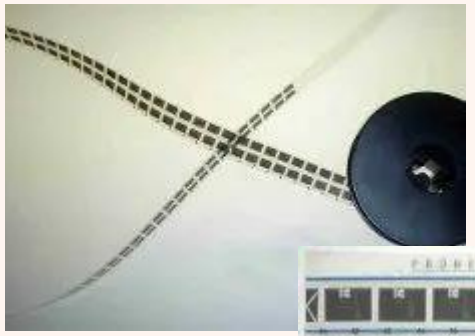
Established method to archive documents, photos as well as documents and drawings, colours available.

Durability is uncertain, data migration is necessary.

Memory capacity is high, data easy to duplicate.

- **Needs equipment, infrastructure (e.g. electric power) and knowledge**
- **Risk of electromagnetic pulse**

Data archiving - microfilm



microfilm
16 mm
35 mm

microfilm-
jacket DIN A6

microfiche DIN A6

© Scamitec

DIN ISO 6199 and other Standards:
Micrographics – Microfilming of Documents

Established method to archive documents, high contrast, no colours.

Durability is guaranteed to be > 100 years.

Memory capacity – about 1,000 pages on one microfiche.

- **Needs equipment**
- **Obviously there is information!**

Data archiving - paper

© LWL-Archivamt für Westfalen

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ISO 9706, DIN 6738 and other Standards:
Paper: Permanence – Durability – Stability

Generally applied method to archive documents, colours included.

Durability is proven to be > 1,000 years for handmade paper, but problems occurred with industrially manufactured paper. Strength was lost within 50 years or less => countermeasures have been developed with high research efforts.

- **Needs no equipment to read information**
- **Obviously there is information!**
- **Proven system for > 1,000 years**
- **Proven restoration methods**
- **Unknown influence of modern paper making additives**

Data archiving with paper - challenges

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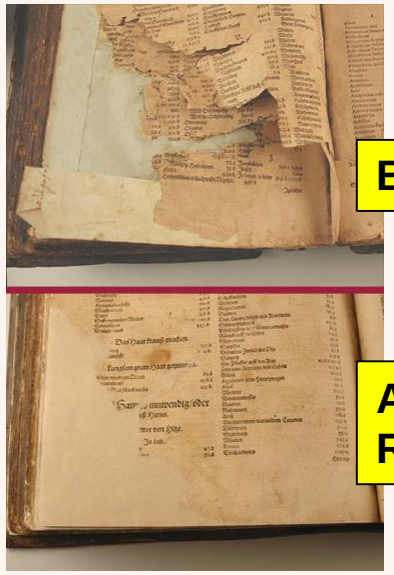

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Main problems:

- **Loss of information due to bleaching (often an ink-problem!)**
- **Loss of mechanical strength due to intrinsic and extrinsic reasons (often a paper-problem!)**

Main countermeasures:

- **Control of paper-manufacturing and used additives**
- **Selection of fibre sources (ISO 9706)**
- **Adjusting a minimum mechanical strength (DIN 6738)**
- **Verification of durability by accelerated ageing and testing (ISO 5630-1 to -7)**
- **Restoration of damage possible**

Data archiving with paper – Labest Papier // well known problems

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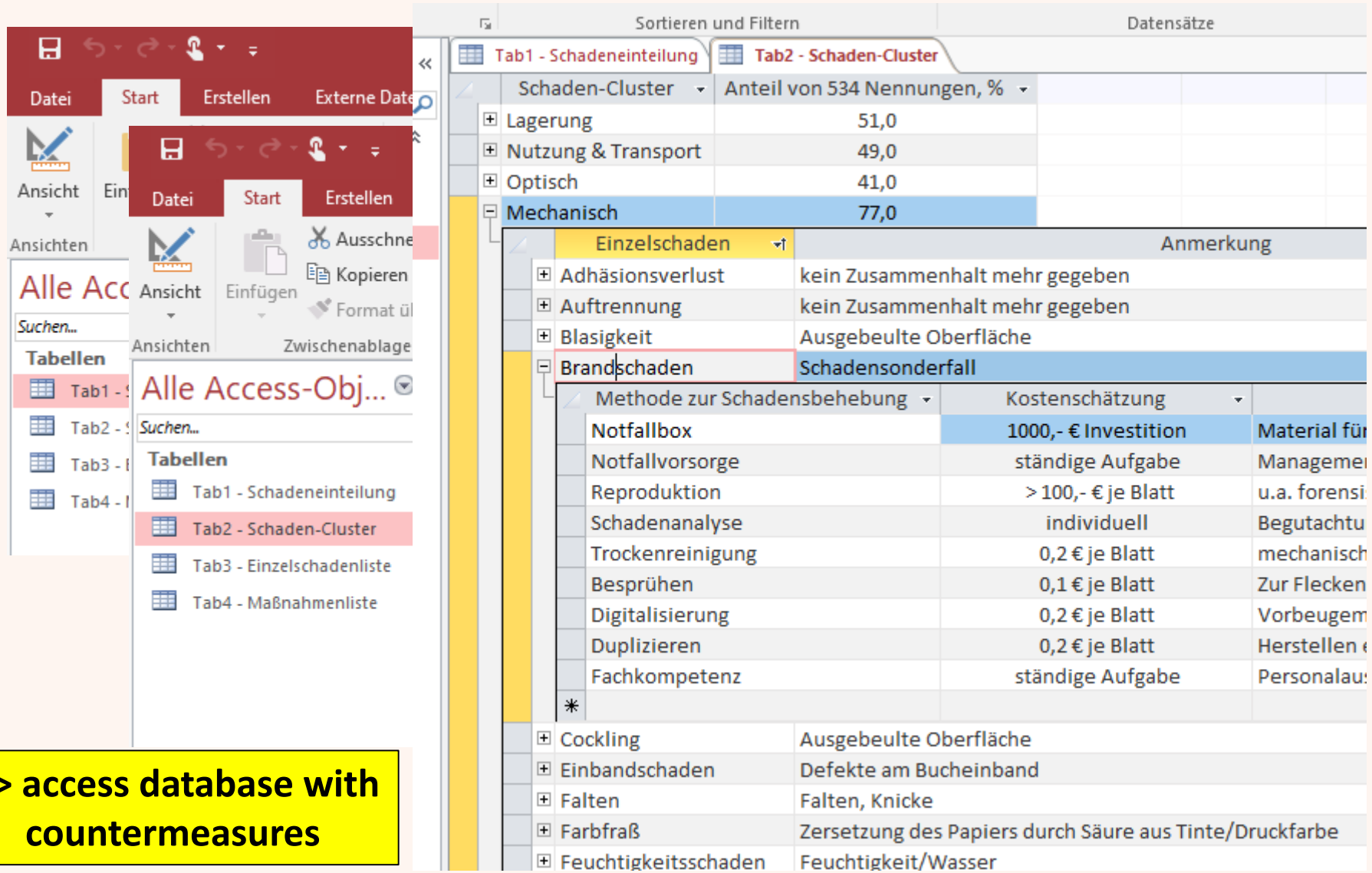

=> access database with countermeasures

Data archiving with paper – Labest Papier // recommendations

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Regarding composition:

- ISO 9706 (no coated paper) / ANSI Z39.48 (with coated paper)
- ISO 11108 (cotton fibres only)
- UNI 10332 (cotton fibres, no heavy metal ions)

© Lecture script Dr. Schaffrath

Regarding ageing and testing:

- DIN 6738 (lifetime class – accelerated ageing)
- ISO 20494 (minimum requirements for ageing tests)
- ISO 5630-x (artificial ageing methods)
- Other specified testing

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Regarding inks:

- ISO 11798 (permanence and durability of inks an paper)
- ISO-series ISO/TS 21139-xx (commercial prints)
- Service regulations for notaries, DONot (durability of documents & anti-counterfeiting)

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Data archiving with paper – Labest Papier // testing

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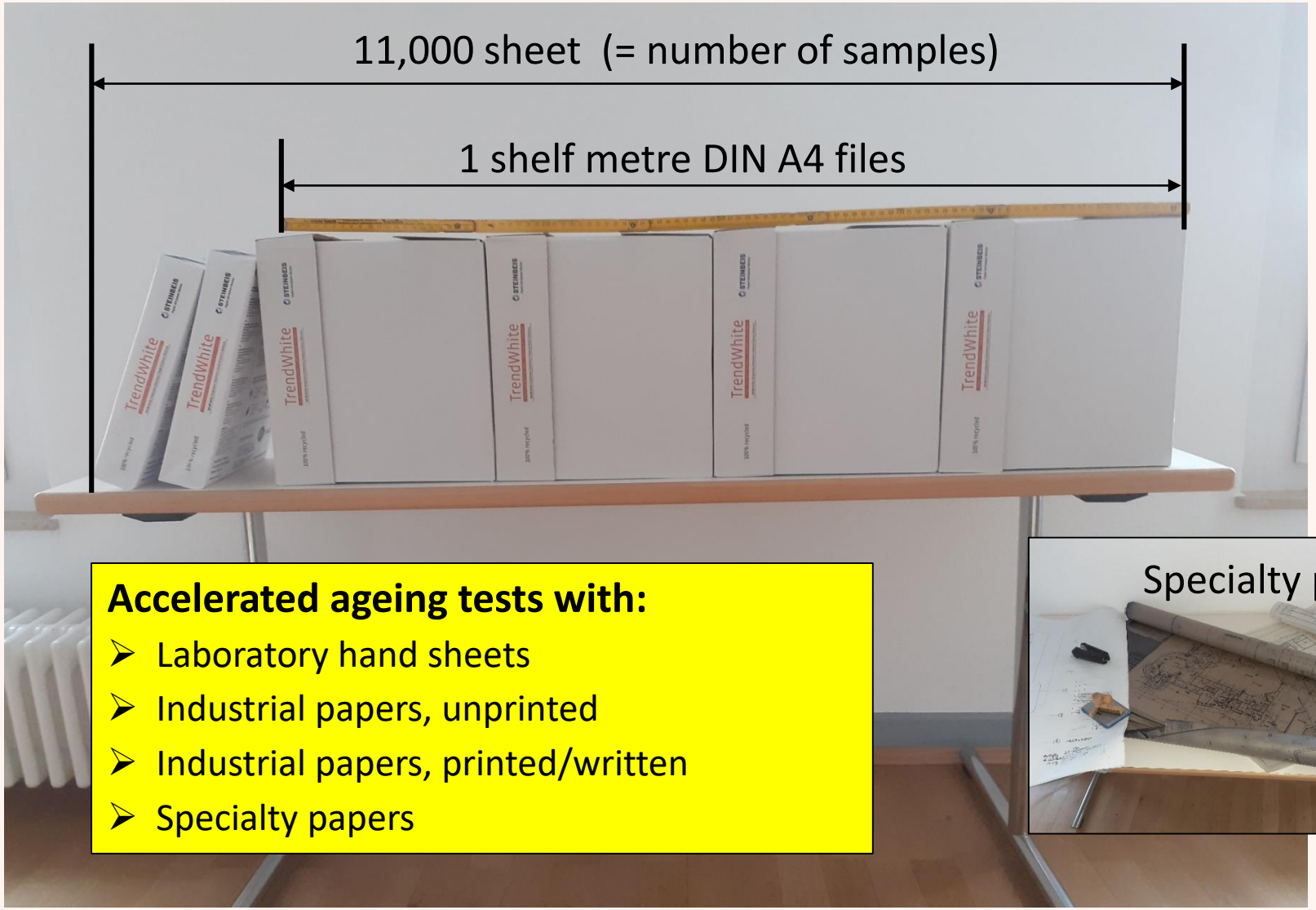

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Accelerated ageing tests with:

- Laboratory hand sheets
- Industrial papers, unprinted
- Industrial papers, printed/written
- Specialty papers

Testing procedure:

1. According to ISO and DIN standards
2. Long term studies up to 16 months
3. Additional testing, e.g. influence of volatile compounds or cross-contamination
4. **ISO 5630-7 has been withdrawn due to Labest Papier ☺ (accelerated ageing by exposure to light)**

Spruce „Alt Tjokko“, Sweden – **9,500 years old**

This impressing long period of time proves the ability of natural polymers, as they are used in paper, to withstand ageing processes.

Who will know in the future?

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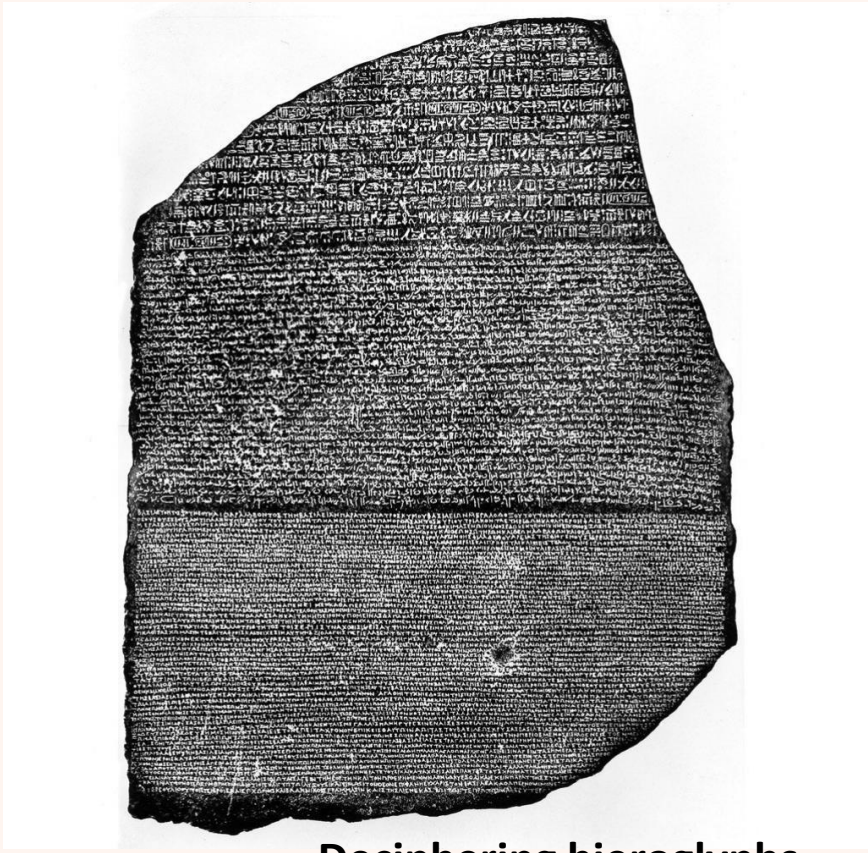

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Deciphering hieroglyphs – the Rosetta stone