Tank Design
Yesterday – Today - Tomorrow

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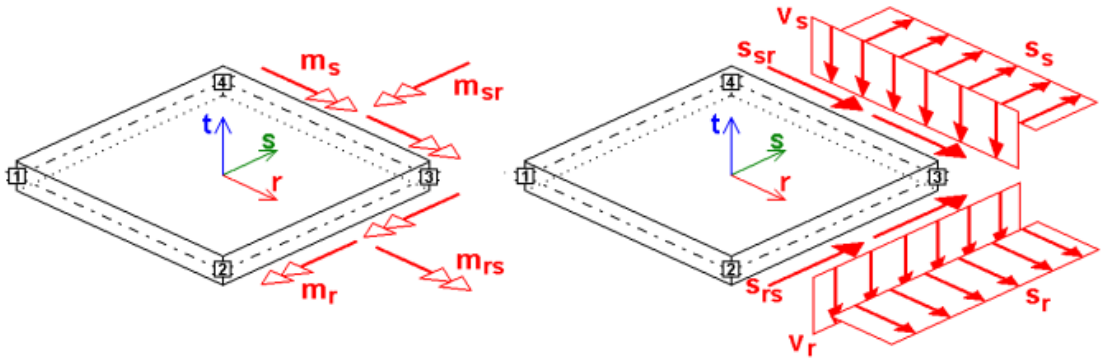
HERBERT LINDEN

Design Methods

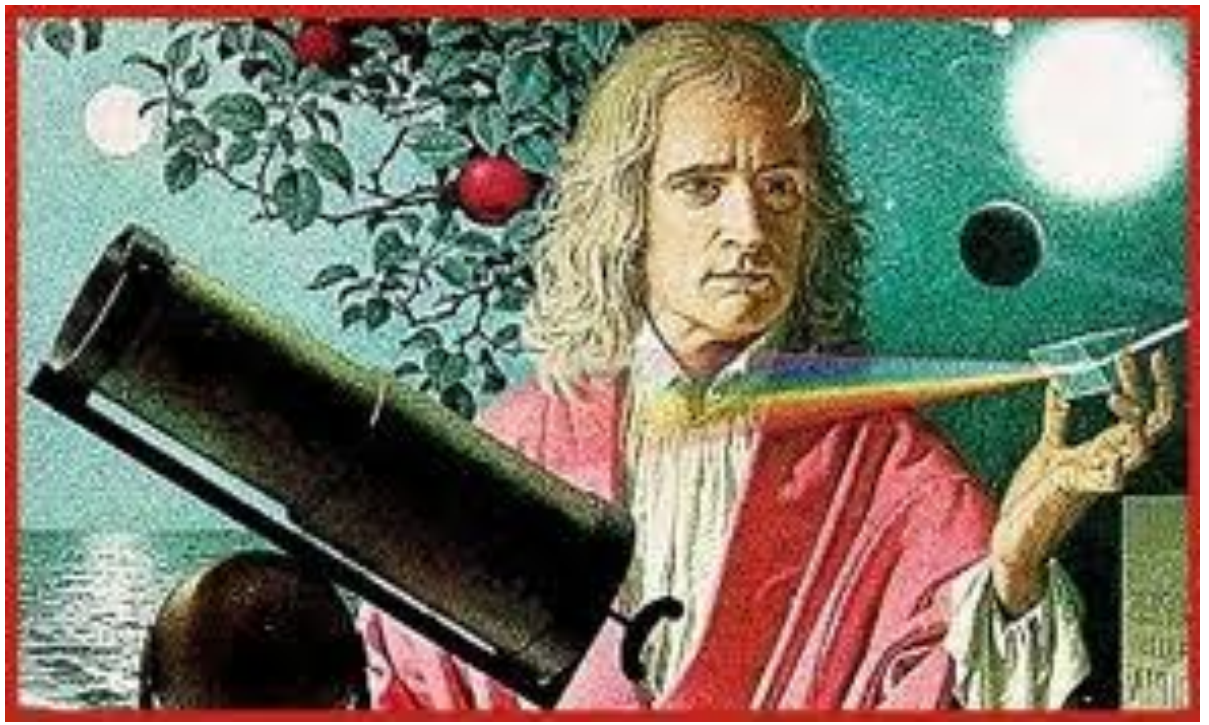
- **Analysis Methods**



$$n^{\alpha\beta} = \int_{-h/2}^{h/2} \left(\delta_\rho^\beta - \theta^3 b_\rho^\beta\right) \sigma^{\alpha\rho} \, d\theta^3 = \tilde{n}^{\alpha\beta} - \tilde{m}^{\alpha\rho} b_\rho^\beta$$

$$m^{\alpha\beta} = \int_{-h/2}^{h/2} \left(\delta_\rho^\beta - \theta^3 b_\rho^\beta\right) \theta^3 \sigma^{\alpha\rho} d\theta^3 = \tilde{m}^{\alpha\beta} - \tilde{\tilde{m}}^{\alpha\rho} b_\rho^\beta \cong \tilde{m}^{\alpha\beta}$$

$$q^\alpha = \int_{-h/2}^{h/2} \sigma^{\alpha 3} \, d\theta^3$$



Design Methods

- Sample Calculations and Standards
  - DVS - Merkblatt 2205 -1 ÷ 2205 - 5
  - Musterberechnung 40 – B1 (Stehende Behälter)
  - Musterberechnung 40 – B2 (Liegende Behälter)
  - Norm prEN 13121

Software

Engineering Software Solutions based

on DVS Merkblätter 2205

- Stable Program Flow ?
- Softwaretechnology State of the Art ?
- All common types of tanks designable ?
- Comfortable data processing ?
- Output checkable?
- Software network- and cloud ready ?

Problem area of the DVS
Example: Rectangular tanks

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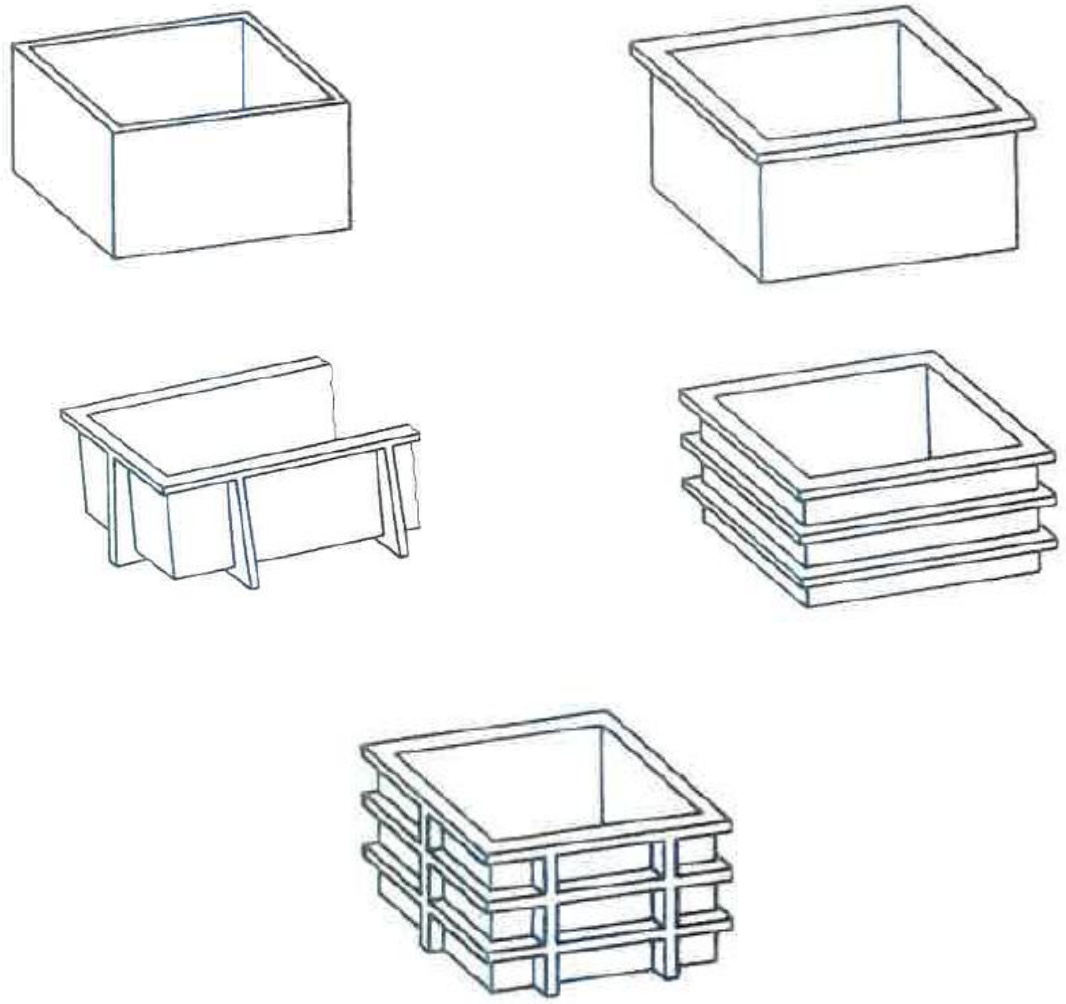
Merkblatt DVS 2205 Teil 5

- The mechanical structual concept very simple
- Restrictive and partially wrong
- No longer contemporary
- No alignment with existing steel design standards
- Uncontrolled mixing within the measurement of modern steel construction standards and the DVS concept



Example of the dimensioning of a rectangular tank with full-perimeter reinforcements

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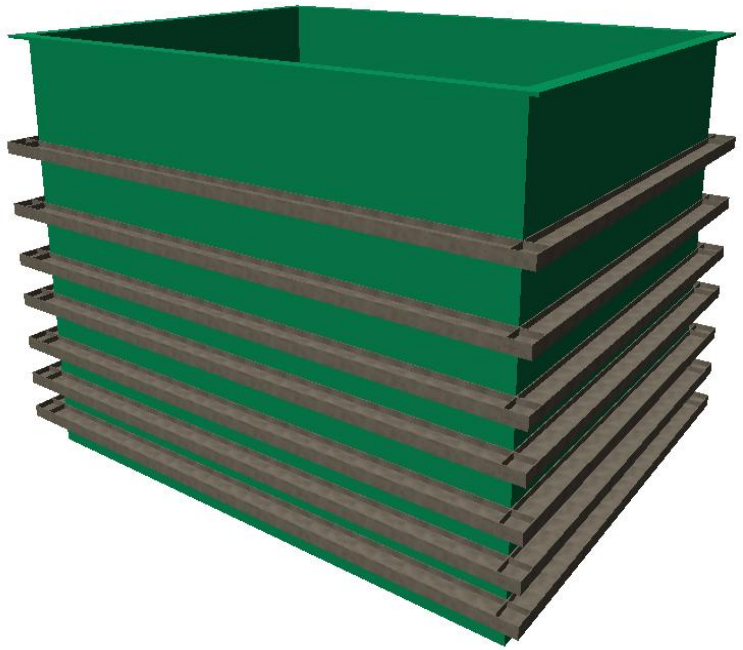
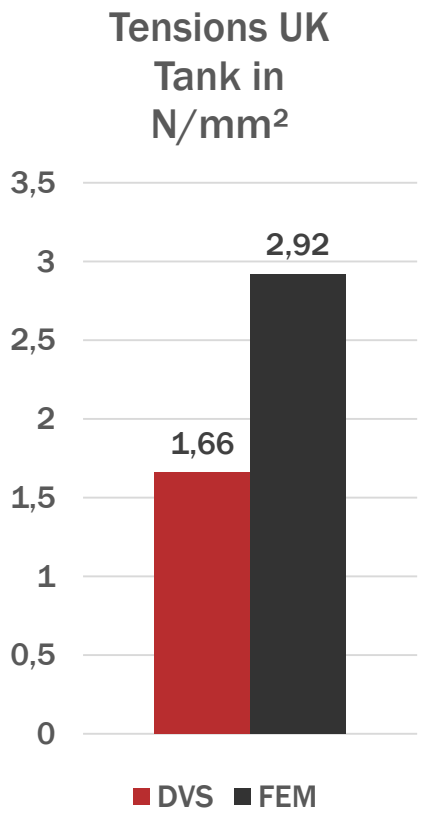
Rectangular tank
h = 3,00 m, b = 4,00 m
Wall thickness
t = 20,00 mm
γ_{Med} = 10,00 kN/m³



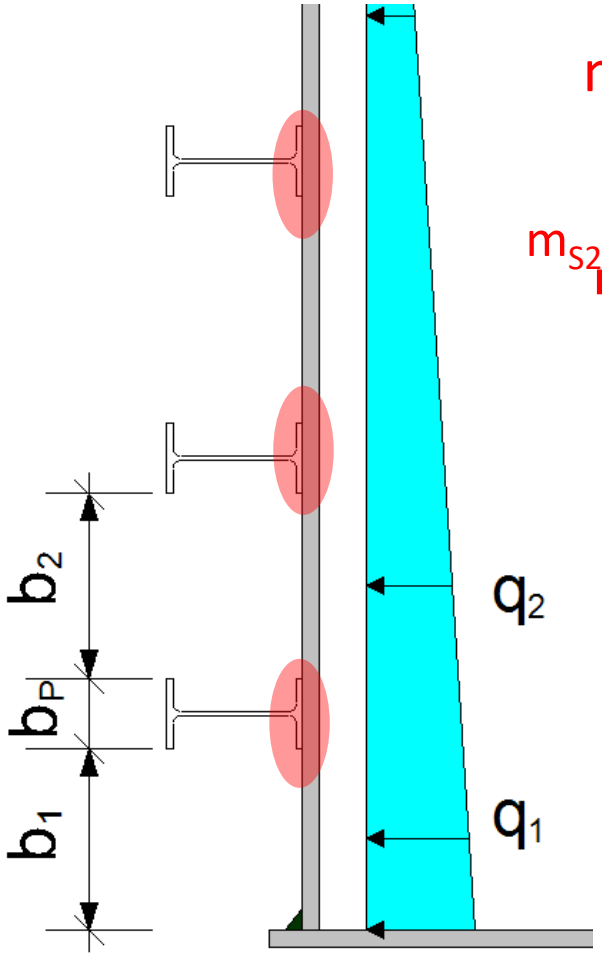


Field Length at the lower edge
b_1= 214 mm

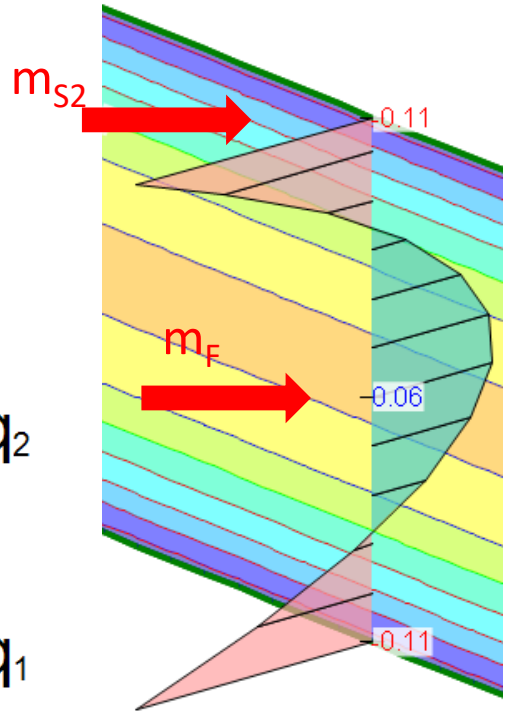
Profile width
b_{Prof} = 82,0 mm (IPE 160)

FEM/DVS = 1,76

Model building at the reinforcement areas for rectangular tanks

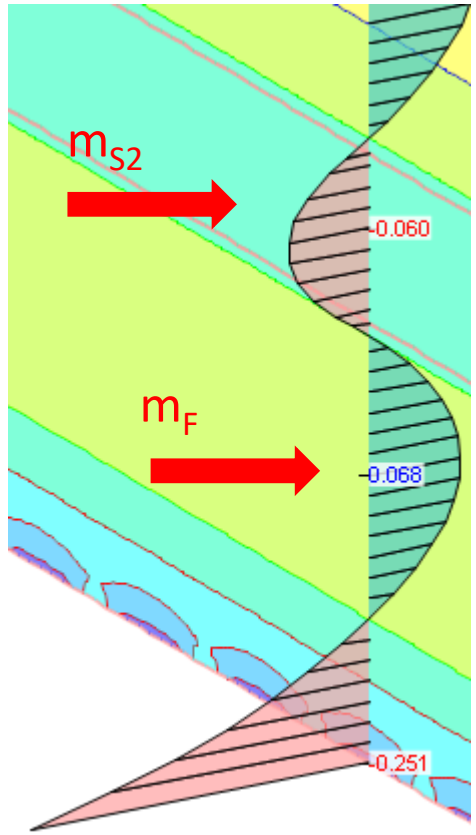


$m_{1d} = q_1 \cdot b_1^2 / 12$



Sidewall model

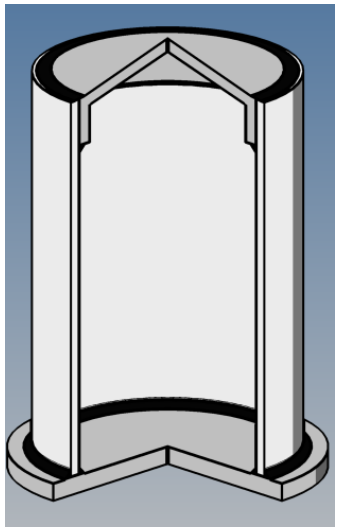
Elastical embedding area

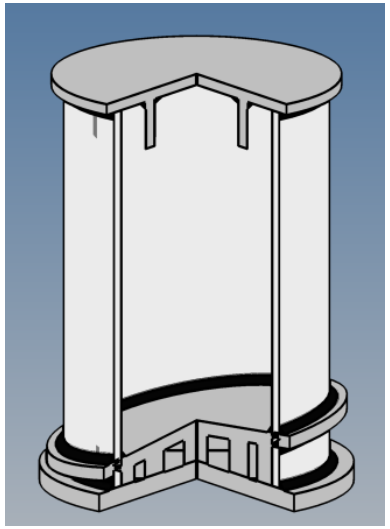


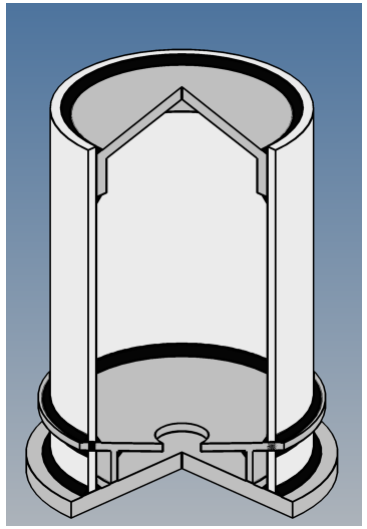
Problem areas of the DVS
Example: Tank bottoms

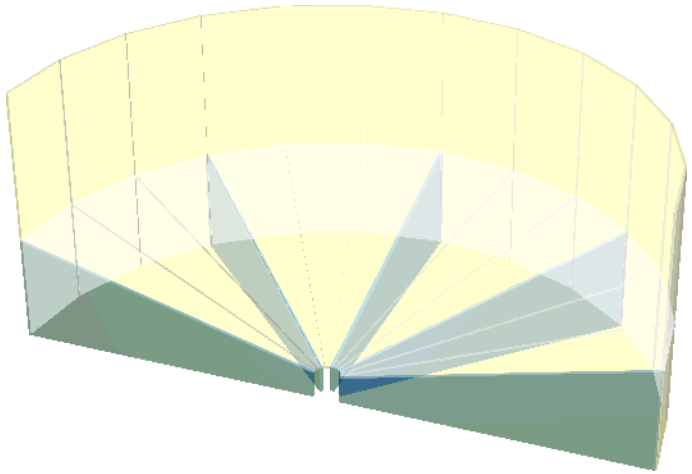
- **Flat bottoms**
  - ✓ State of the Art
- **Sloped bottoms**
  - ✓ Constructionally complex but possible
- **Ring supported conical bottoms**
  - ✓ Constructionally complex
  - ✓ All adoptions of the model building constructionally possible?
- **Segment bottoms**
  - ✓ Constructionally a quite simple construction
  - ✓ Many statical Advantages

Currently no regulations for the design









FEM

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Finite Elemente Method

- Dlubal
- Microfe
- Ansys
- Adina
- Abacus

and many , many more

MicroFE

Finite Elemente

Disadvantages of the FEM

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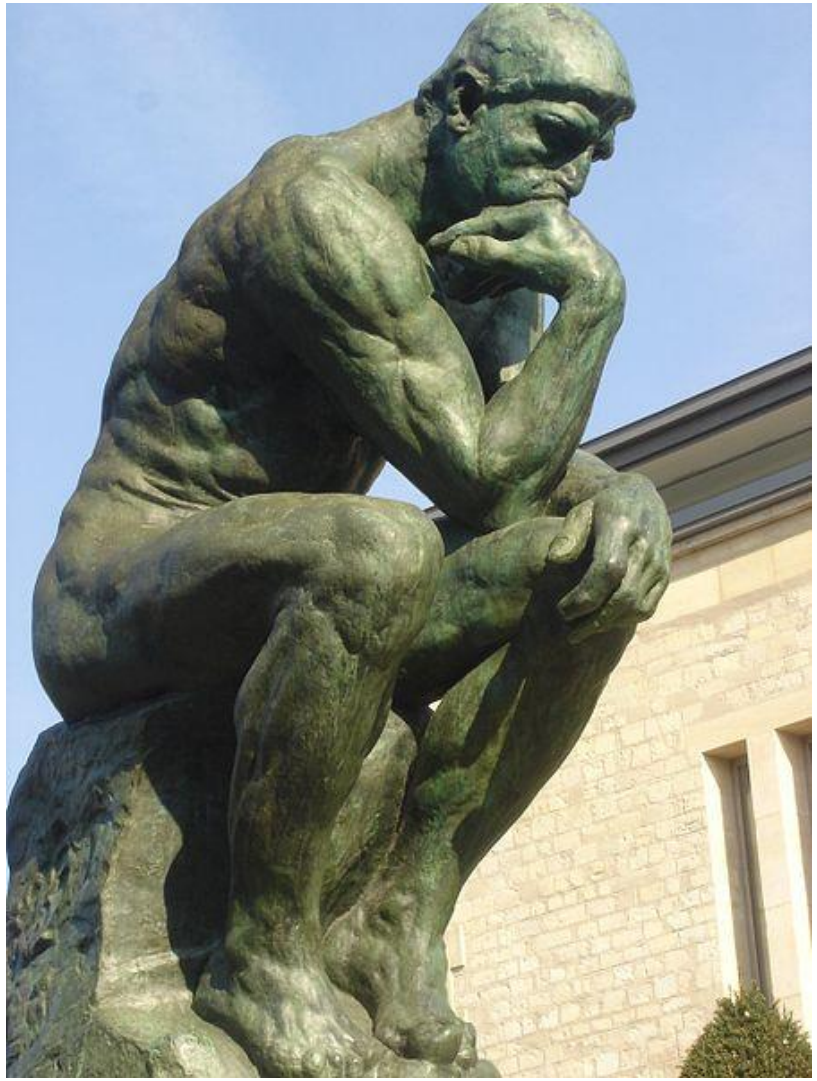
Finite Elemente Method

- High initial costs
- Long training period
- Only qualified personnel
- Work- and time-consuming project handling



Tank dimensioning of tomorrow

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How does it work?

- Core Software
- Software Organization
- Access to the Software
- Data structure

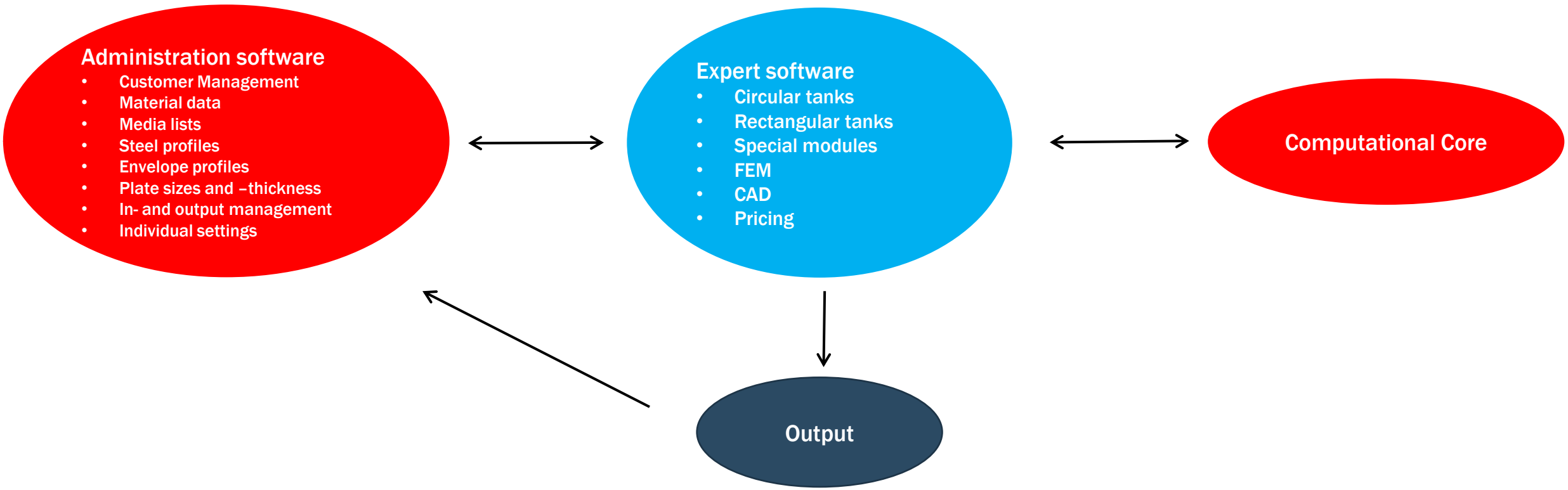
Core software

- Object-oriented programming
- Intuitive user guidance
- Stable program flow with high performance
- Input check

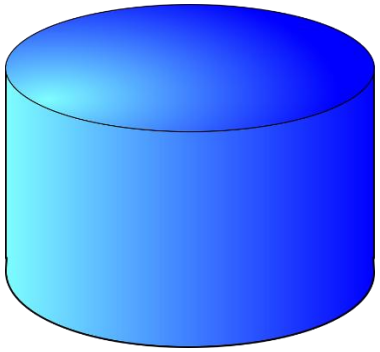
  Validation instead of error messages
- Structured data saving → XML (human readable)
- Clear and strict seperation between In-/Output and the real data

  → Layer model

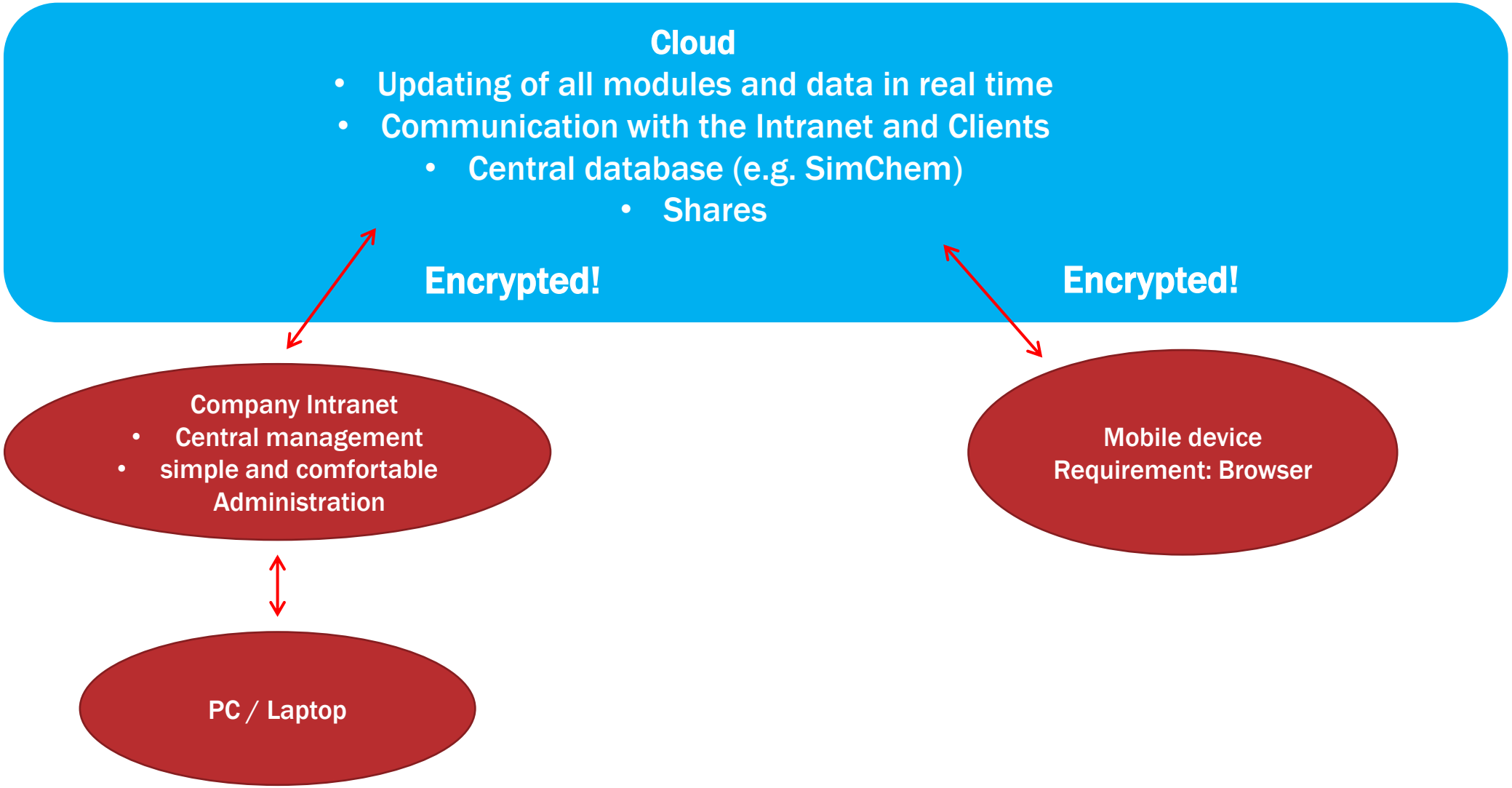
Layer model


Administration software
Customer Management
Material data
Media lists
Steel profiles
Envelope profiles
Plate sizes and –thickness
In- and output management
Individual settings
Expert software
Circular tanks
Rectangular tanks
Special modules
FEM
CAD
Pricing
Computational Core
Output

Access to the Software



Softwareorganization



Summary

What is essential?

- Object-oriented programming
- Stable programm flow with validation
- Structured data storage and exchange formats
- Comfortable administration module

What is desirable?

- Universal communication
- Integrated additional tools (FEM, CAD, Pricing)
- Real Time Updates and Cloud capability

Where does this lead to?

User ⟷ Software producer

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