

Adatgyűjtés és adatbázis támogatás az elosztóhálózati kábelek állapotvezérelt karbantartásához (CBM)

Edward Gulski, Ben Quak
Edwin Groot (*)

(*) Delft University of Technology, HV Technology & Management, The Netherlands
(3) NUON InfraCore, The Netherlands

Adatgyűjtés és adatbázis támogatás az elosztóhálózati kábelek állapotvezérelt karbantartásához

TARTALOM

1. Általános szempontok
2. Adatbázis struktúra
3. Adatintegritás
4. Felhasználási módok
5. Következtetések

Adatgyűjtés és adatbázis támogatás az elosztóhálózati kábelek állapotvezérelt karbantartásához

TARTALOM

1. Általános szempontok

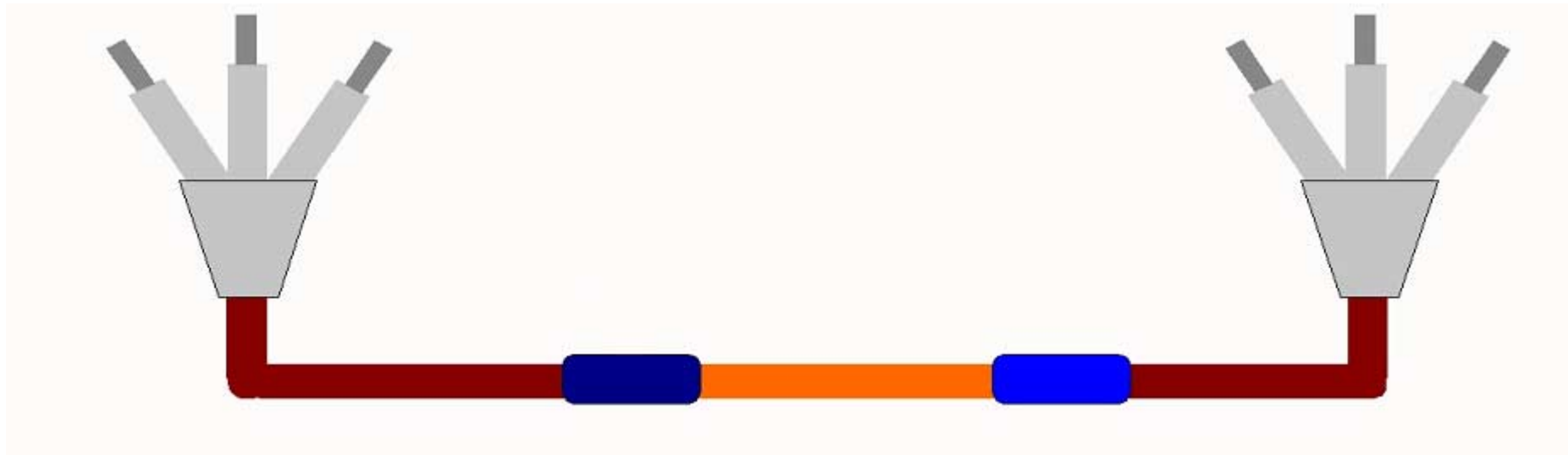
2. Adatbázis struktúra

3. Adatintegritás

4. Felhasználási módok

5. Következtetések

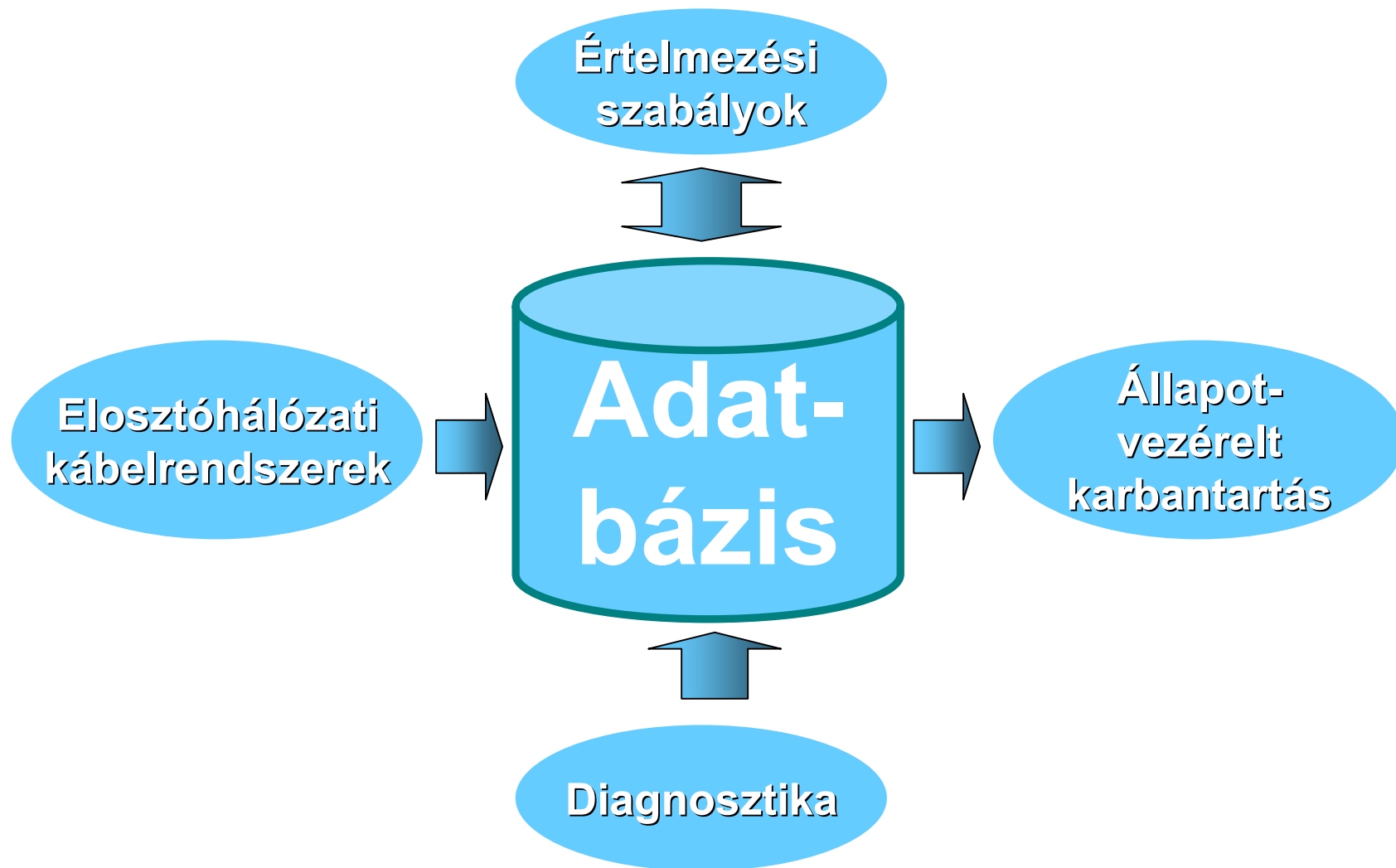
Erősáramú kábelrendszerek



Kábelszakasz:

- Kábel
- Összekötők
- Végelzárók

- Különböző típusok
- Különböző életkor
- Különböző múlt



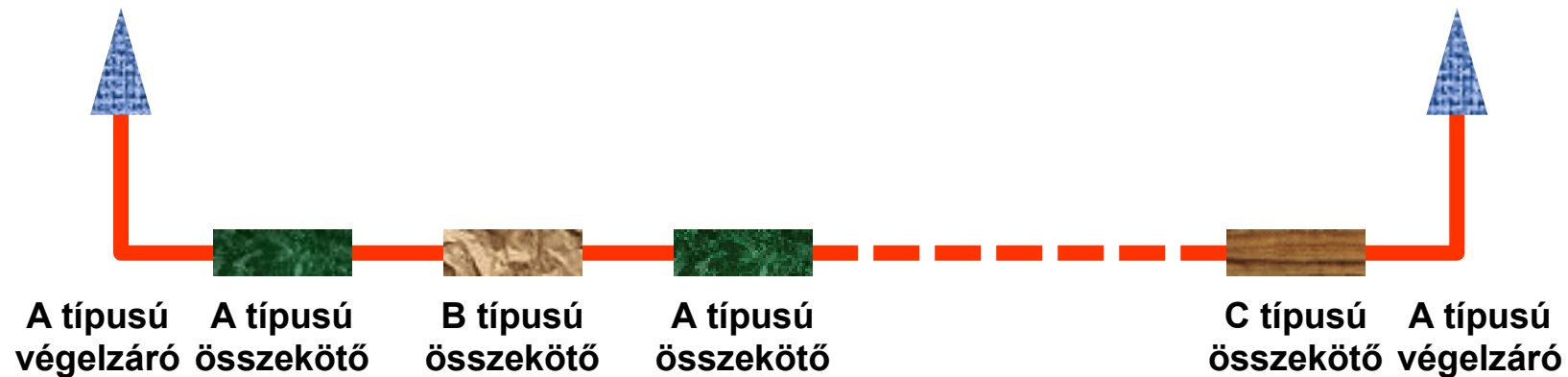
A villamosmérnökök támogatására a diagnosztikai eredmények értelmezésében és az erősáramú kábelek szigetelési állapotának megítélésében, a következő információkat kell összekapcsolni és felhasználni a döntéshez szükséges ismeretek előállításakor:

Komponens terület; tartalmazza a kábel felépítésének specifikus szigetelési jellegzetességeit; pl. kábelszigetelés, szerelvények,

Diagnosztikai terület; tartalmazza az alkalmazott diagnosztika típusát; pl. általános állapot megítélése, gyengepontok felderítése

Mérési adatok területe; az állapotértékelés során felhasznált specifikus diagnosztikai mennyiségek meghatározása.

Adatbáziselemzés: az aktuális szigetelési állapot értékelése

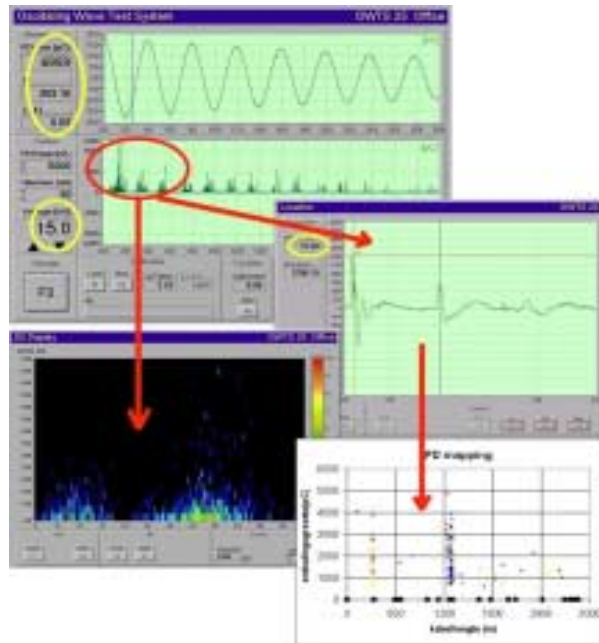


⇒ a mérési adatok tárolása;

⇒ korreláció a lényeges értelmezési szabályok között;

⇒ a karbantartási javaslatokhoz szükséges bonyolult információk kinyerése;

Adatbáziselemzés: Részleges kisülés mennyiségek kiértékelése



- PDIV (Begy. fesz.);
- PDEV (Kialv. fesz.);
- PD szint;
- PD intenzitás;
- PD minta (fázishelyzet);
- PD térkép;
- $\text{tg } \delta$.

A kábel szigetelési állapota 1, 2 és 3 dimenziós mérési mennyiségek alapján elemezhető:

⇒ Eredmények összevetése: PD minta, PD térkép, $\text{tg } \delta$ különböző feszültségigénybevételek esetén;

⇒ A különbségek trendelése az üzem alatti kritikus változások szempontjából, pl. *trendanalízis*;

⇒ A hasonló komponensek eredményeinek összevetése pl. *statisztikai eltéréselemzés*.

Adatgyűjtés és adatbázis támogatás az elosztóhálózati kábelek állapotvezérelt karbantartásához

TARTALOM

1. Általános szempontok

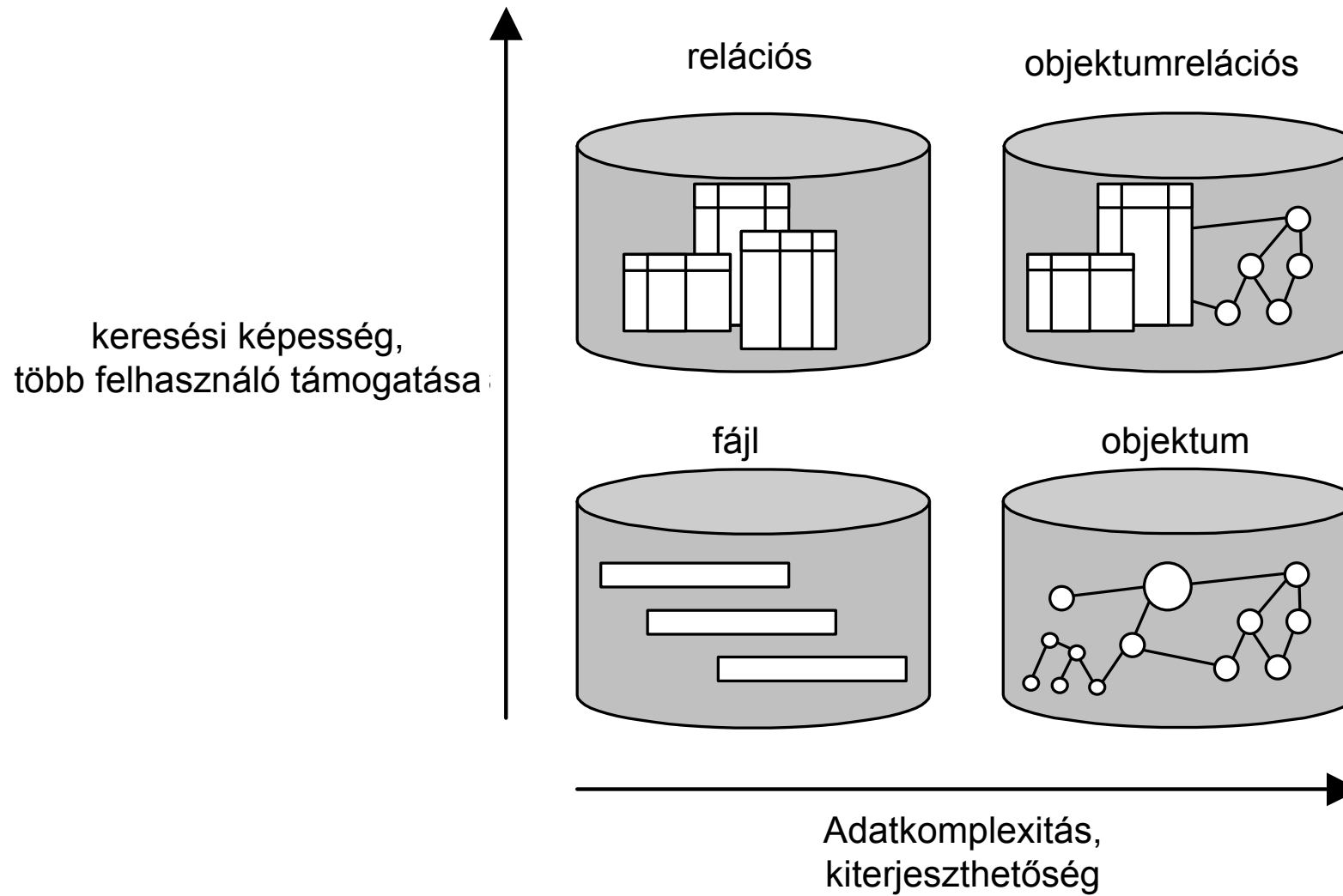
2. Adatbázis struktúra

3. Adatintegritás

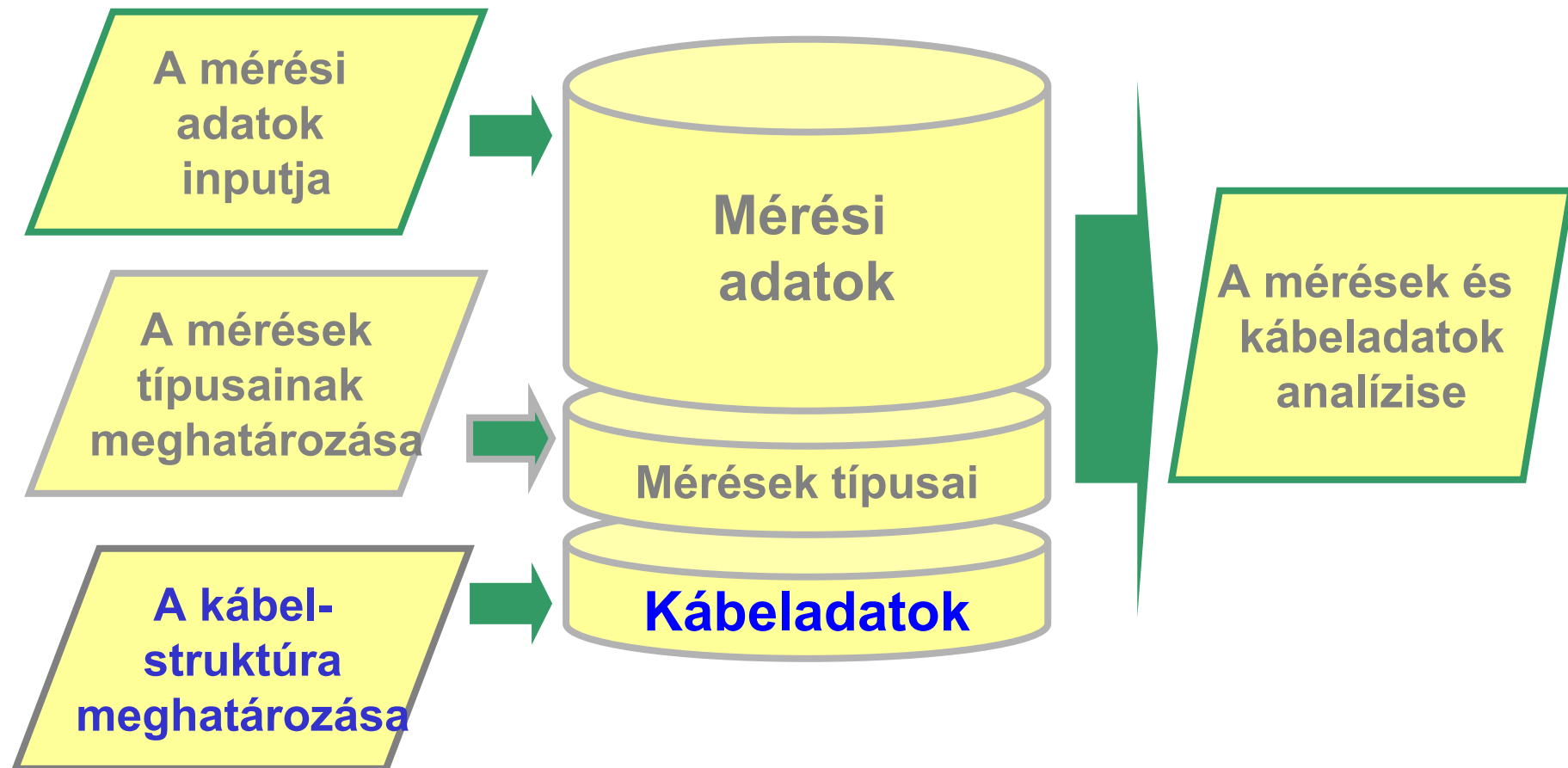
4. Felhasználási módok

5. Következtetések

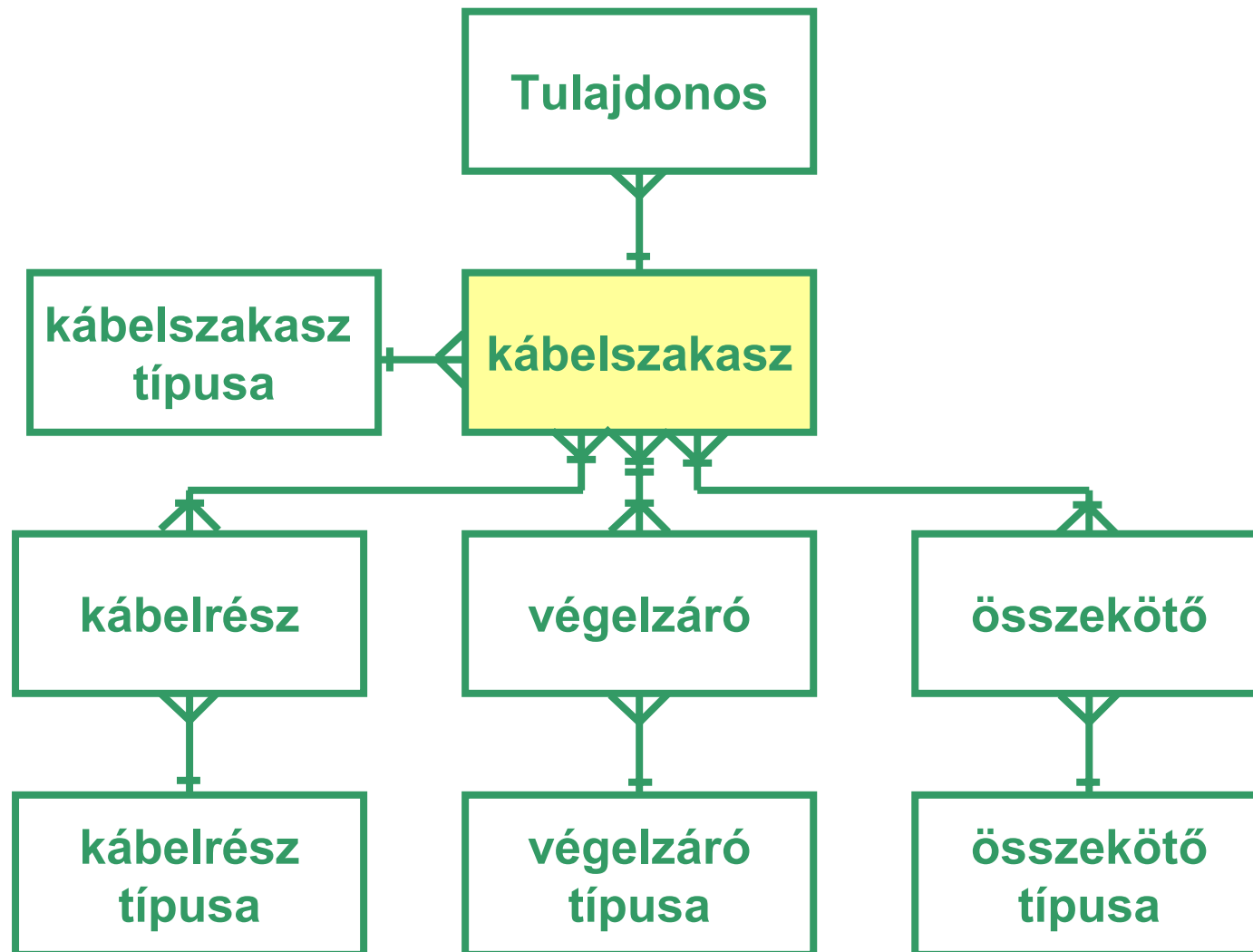
Az adatbázis rendszer



Az adatbázis rendszer



Kábel-terület



Cable Sections



Cable Sections



Norms



Types



Persons



Help



Exit

Cable sections

6572 - Forbo k4 / 402 - 50KV Krommenie
7885 - Forbo k15 / 402 - 50kv Krommenie
6570 - Forbo k2 / 402 - 50 kV Krommenie
6569 - Forbo k1 / 402 - 50kV Krommenie
7652 - Middenakker / 406 - 50KV Purmerend KK
OSwH 670729
OSwH 288522
50kV Rijnsburg kabel veld 115 groep 7000 naar AKZO
50kV Rijnsburg kabel veld 115 groep 7000 naar AKZO
Test Cable 1
Test Cable 2
Test Cable 2
Test Cable 3

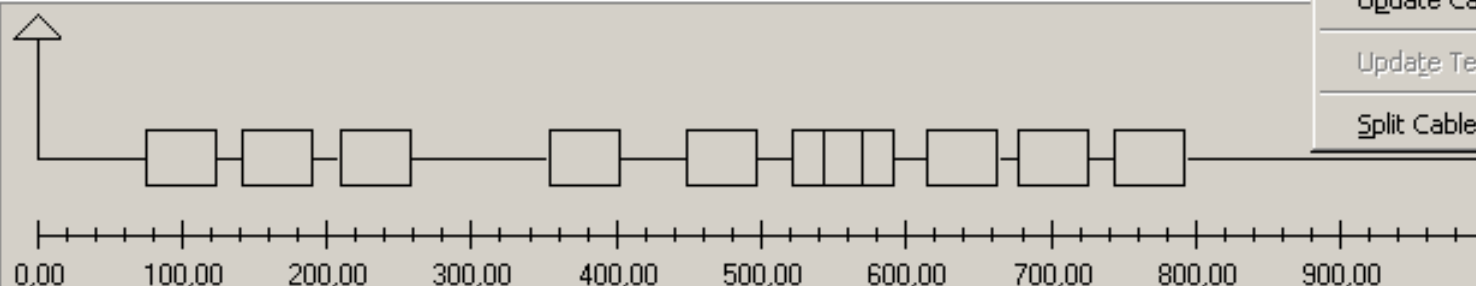
Add

Update

Join sections

Delete

Graphical



Cable section Information

Name: Test Cable 1
Type: Cable Section Test Type I
Voltage Class: 10
City: Delft
Owner: TestPerson
Section number: 9676068
Load: Unknown
Earthing faults: None
Soil conditions: Unknown
History:

Add joint

Update Joint

Delete Joint

Update Cable part

Update Termination

Split Cable section



Cable Sections



Cable Sections



Norms



Types



Persons



Help



Exit

Cable sections

6572 - Forbo k4 / 402 - 50KV Krommenie
7885 - Forbo k15 / 402 - 50kv Krommenie
6570 - Forbo k2 / 402 - 50 kV Krommenie
6569 - Forbo k1 / 402 - 50kV Krommenie

7652 - Middenakker /
OSwH 670729
OSwH 288522
50kV Rijnsburg kabel
50kV Rijnsburg kabel
Test Cable 2
Test Cable 4
Test Cable 3
Test Cable 1

Add joint

Joint type

Conductor type

Serial number

Mounting date

Distance left cable part ending m

Distance right cable part ending m

Distance end of cable section m

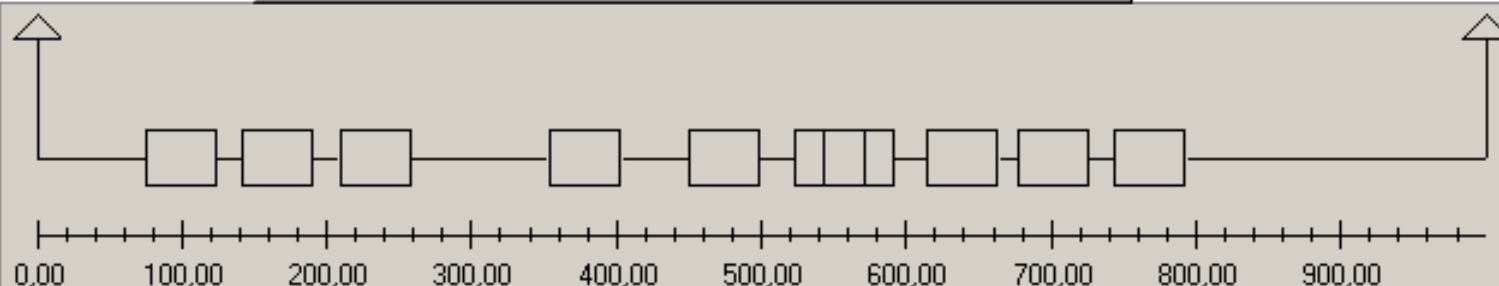
OK

Cancel

Cable section Information

Name Type

Graphical



Types

Cable Sections

Norms



Types



Persons



Help



Exit

Cable component types | Cable section types

Cable part types

TKF 150 AL
TKF 95 CU
NKF 95 CU
Unknown 95 CU
VOHW 95 CU
TKF 240 AL
AA150AL
AA95AI

Add

Update

Delete

Name

TKF 150 AL

Manufacturer

TKF

Insulation type

Paper Oil

Conductor type

150AL

Joint types

Lovisil
Oliemof
Tece
Unknown
Kabeldon
Nekaldiet
Joint TestType A
Joint TestType B

Add

Update

Delete

Name

Manufacturer

Insulation type

Termination types

Coq
Magnefix
Capitole
Onbekend ES O 47
Unknown
Termination TestType 1
Termination TestType 2

Add

Update

Delete

Name

Manufacturer

Insulation type

Persons



Norms



Types



Persons



Help



Exit

Persons

Nuon
Benjamin Quak
TUDelft
Ben Quak
TestPerson
TestPerson number 2

Name TestPerson number 2

Address Mekelweg 4

Zip 2628CD

City Delft

Phone 0152789111

Info TestPerson number 2 is een inspector voor test doeleinden.

☐ Customer ☒ Inspector

Add

Update

Delete

Norms


Cable Sections

Norms



Types



Persons



Help



Exit

Quantities and Component types

Measurement type OWTS

Component

- ☐ Termination
☒ Joint
☐ Cable part
☐ Cable section

Component type

Tece
Unknown
Kabeldon
Nekaldiet
Joint TestType A
Joint TestType B

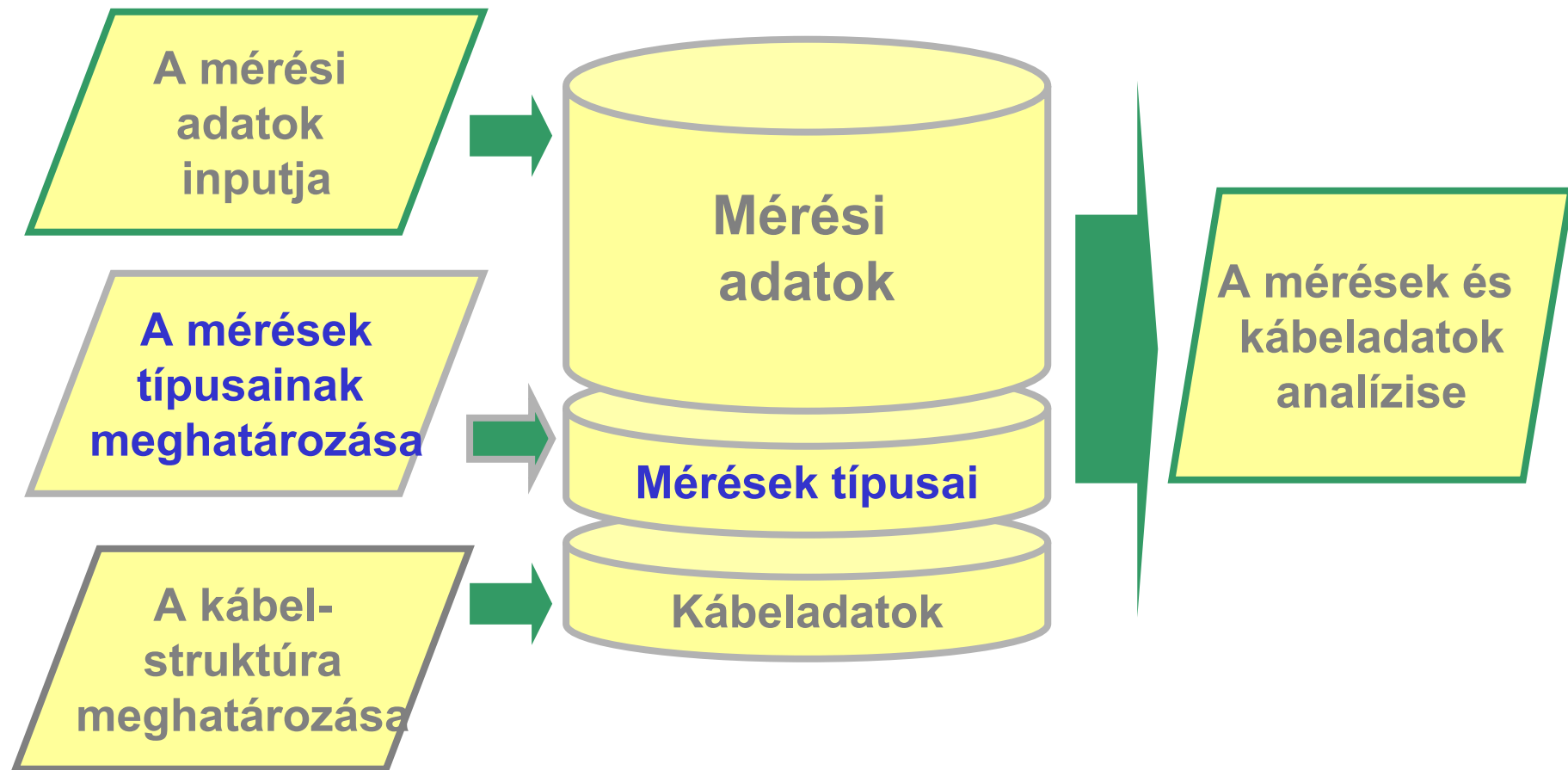
Quantity

PD level at U_0
PD level at 2*U_0
PD intensity at U_0
PD intensity at 2*U_0

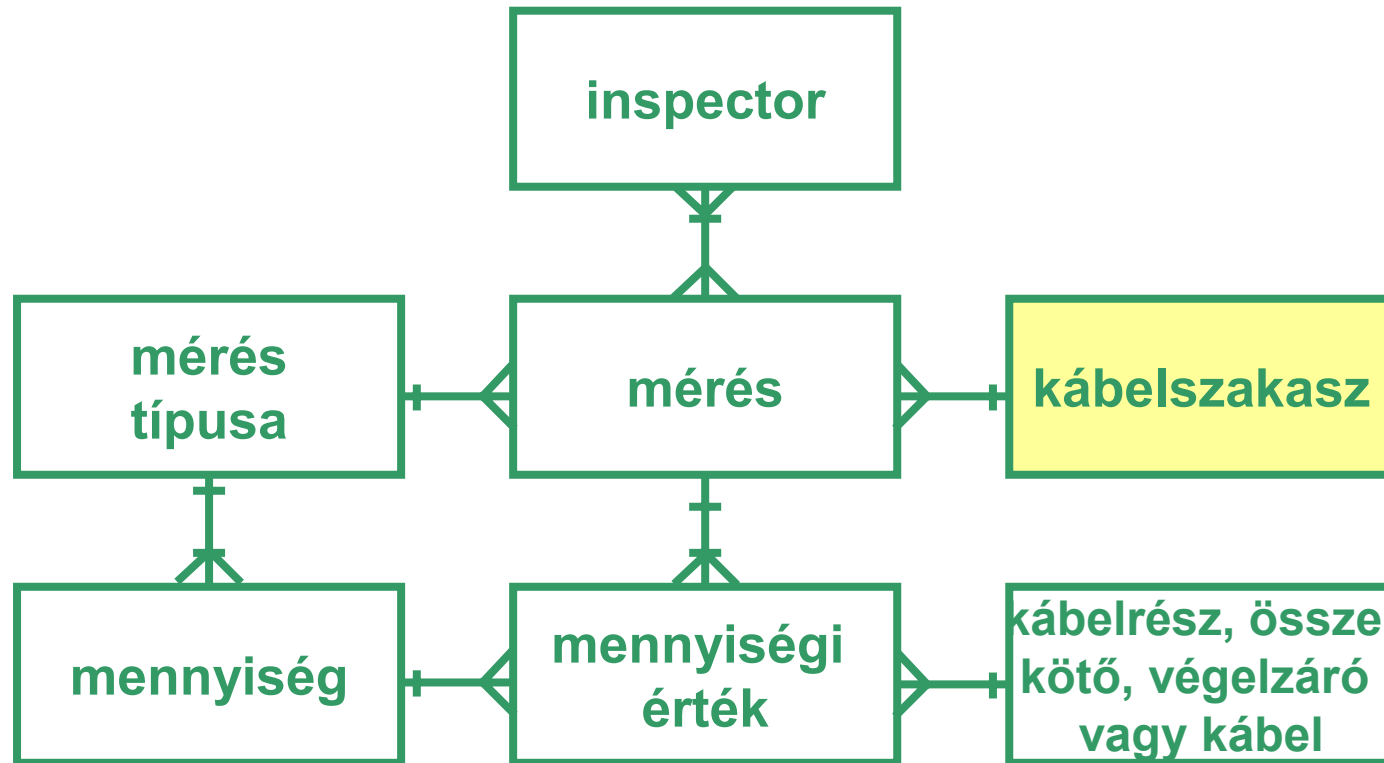
Norm (numerical)

Minimum value Common value Maximum value

Az adatbázis rendszer



Mérési terület





Types



Choices



Help



Exit

Measurement Types

Measurement type

OWTS

New

Delete

1D Quantities

2D Quantities

3D Quantities

Comment

PDIV

PDEV

PD level at U_0

PD level at U_0

PD level at U_0

PD level at U_0

PD level at 2*U_0

PD level at 2*U_0

PD level at 2*U_0

PD level at 2*U_0

Tg Delta at U_0

Tg Delta at 2*U_0

PD intensity at U_0

PD intensity at U_0

PD intensity at U_0

PD intensity at U_0

PD intensity at 2*U_0

PD intensity at 2*U_0

PD intensity at 2*U_0

PD intensity at 2*U_0

Condition

Update 1D quantity

Name

PD level at 2*U_0

Type

Numerical

Numerical

Unit

pC

Low value

0,00000

High value

1000000,00000

Apply to

CableSection

OK

Cancel

Add

Update

Delete



Types



Choices



Help



Exit

Measurement Types

Measurement type

OWTS

New

Delete

1D Quantities

2D Quantities

3D Quantities

PD Mapping at U_0

PD Mapping at 2*U_0

PD-time at U_0

PD-time at 2*U_0

U-time at U_0

U-time at 2*U_0

Name PD Mapping at U_0

Number of lines to skip

3

Data column

1

First dimension/column

Axis ☒ X ☐ Y

Axis label Cable Length

Unit m

Second dimension/column

Axis ☐ X ☒ Y

Axis label PD magnitude

Unit pC

Graph type ☐ Line ☒ Scatter ☐ Spike

Apply to CableSection

Add

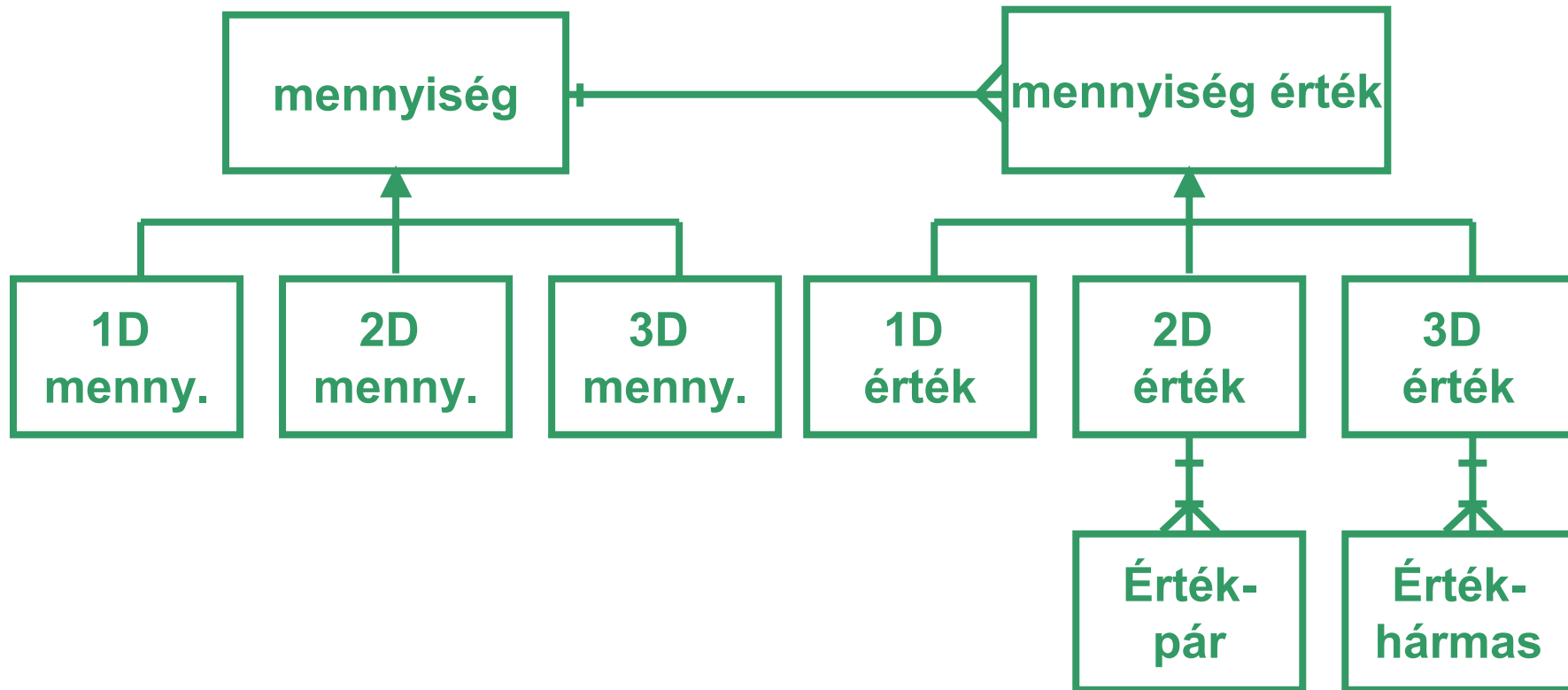
Update

Delete

Az adatbázis rendszer



Mennyiség-terület



1D:

Numerikus érték

Szöveges érték

Többválasztásos érték

2D:

A numerikus
párok listája

3D:

A numerikus
hármassok listája



Selection



Measurement



Help



Exit

Selection

Measurement type

OWTS

Component

- ☒ CableSection
 - 6572 - Forbo k4 / 402 - 50KV Krommenie - Krommenie - GPLK
 - 7885 - Forbo k15 / 402 - 50kv Krommenie - Krommenie - GPLK
 - 6570 - Forbo k2 / 402 - 50 kV Krommenie - Krommenie - GPLK
 - 6569 - Forbo k1 / 402 - 50kV Krommenie - Krommenie - GPLK
 - 7652 - Middenakker / 406 - 50KV Purmerend KK - - GPLK
 - OSWH 670729 - Amsterdam - GPLK
 - OSWH 288522 - Amsterdam - GPLK
 - 50kV Rijnsburg kabel veld 115 groep 7000 naar AKZO - - GPLK
 - 50kV Rijnsburg kabel veld 115 groep 7000 naar AKZO - - GPLK
 - Test Cable 1 - Delft - Cable Section Test Type I**
 - Test Cable 2 - - Cable Section Test Type I
 - Test Cable 4 - - Cable Section Test Type I
 - Test Cable 3 - - Cable Section Test Type I
 - Test Cable 1 - Delft - Cable Section Test Type I



Selection



Measurement



Help



Exit

Measurement

Measurements

L1 10-3-1998

L2 10-3-1998

L3 10-3-1998

L1 31-10-1998

L2 31-10-1998

L3 31-10-1998

L1 02-02-1999

L2 02-02-1999

L3 02-02-1999

L1 05-03-2000

L2 05-03-2000

L3 05-03-2000

L1 03-04-2001

L2 03-04-2001

L3 03-04-2001

Add

Copy

Update

Delete

Measurement Info

Name

L1 10-3-1998

Date

10-3-1998 13:50:33

Inspectors

TestPerson number 2

Measurement

Update measurement

Information | Quantities

Measurement Info

Name

L1 30-11-1999

Date

30-11-1999

0:00:00

Inspectors

- ☒ Benjamin Quak
- ☐ Ben Quak
- ☐ TestPerson number 2

Select All

Deselect All

Invert Selection

OK

Cancel



Selection



Measurement



Help



Exit

Measurement

Update measurement



Information

Quantities

Components

[-] 6572 - Forbo k4 / 402

[-] CablePart

- TKF 150 AL
- TKF 95 CU
- TKF 150 AL
- TKF 95 CU
- NKF 95 CU
- TKF 150 AL
- TKF 95 CU
- TKF 150 AL
- TKF 95 CU
- TKF 95 CU

[-] Joint

- Lovisil
- Lovisil
- Lovisil
- Oliemof
- Tece
- Tece
- Lovisil
- Lovisil
- Lovisil

[-] Termination

Quantities

1D Quantities

2D Quantities

3D Quantities

Comment

PDIV

kV

PDEV

kV

PD level at U₀

pC

PD level at 2*U₀

pC

Tg Delta at U₀Tg Delta at 2*U₀PD intensity at U₀PD intensity at 2*U₀

Condition

PD level at PDIV

pC

OK

Cancel

Selection

Measure



Help



Exit

Measurement

Update measurement



Information

Quantities

Components

[-] 6572 - Forbo k4 / 402

[-] CablePart

- TKF 150 AL
- TKF 95 CU
- TKF 150 AL
- TKF 95 CU
- NKF 95 CU
- TKF 150 AL
- TKF 95 CU
- TKF 150 AL
- TKF 95 CU
- TKF 95 CU

[-] Joint

Lovisil

Lovisil

Lovisil

Oliemof

Tece

Tece

Lovisil

Lovisil

Lovisil

[-] Termination

Quantities

1D Quantities

2D Quantities

3D Quantities

PD level at U_0 pCPD level at 2*U_0 pC

PD intensity at U_0 <<< No value >>> ▼

PD intensity at 2*U_0 Low ▼

OK

Cancel



Help



Exit

Measurement

Update measurement



Information

Quantities

Components

[-] 6572 - Forbo k4 / 402

[-] CablePart

... TKF 150 AL

... TKF 95 CU

... TKF 150 AL

... TKF 95 CU

... NKF 95 CU

... TKF 150 AL

... TKF 95 CU

... TKF 150 AL

... TKF 95 CU

... TKF 95 CU

[-] Joint

... Lovisil

... Lovisil

... Lovisil

... Oliemof

... Tece

... Tece

... Lovisil

... Lovisil

... Lovisil

[+] Termination

Quantities

1D Quantities

2D Quantities

3D Quantities

PD Mapping at U_0

PD Mapping at 2*U_0

PD-time at U_0

PD-time at 2*U_0

U-time at U_0

U-time at 2*U_0

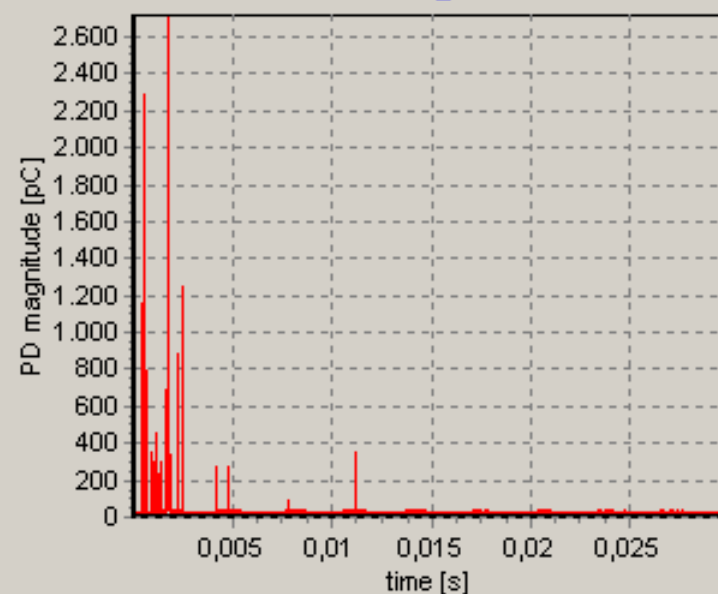
Import

Delete

Table



PD-time at 2*U_0



OK

Cancel

Selection

Measure



Help



Exit

Adatgyűjtés és adatbázis támogatás az elosztóhálózati kábelek állapotvezérelt karbantartásához

TARTALOM

1. Általános szempontok

2. Adatbázis struktúra

3. Adatintegritás

4. Felhasználási módok

5. Következtetések

Az adatbázis rendszer



Adatintegritás

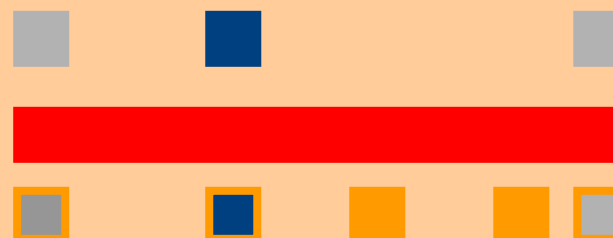
javítás előtti helyzet



javítás utáni helyzet



Érvényes mérési adatok



Adatgyűjtés és adatbázis támogatás az elosztóhálózati kábelek állapotvezérelt karbantartásához

TARTALOM

1. Általános szempontok

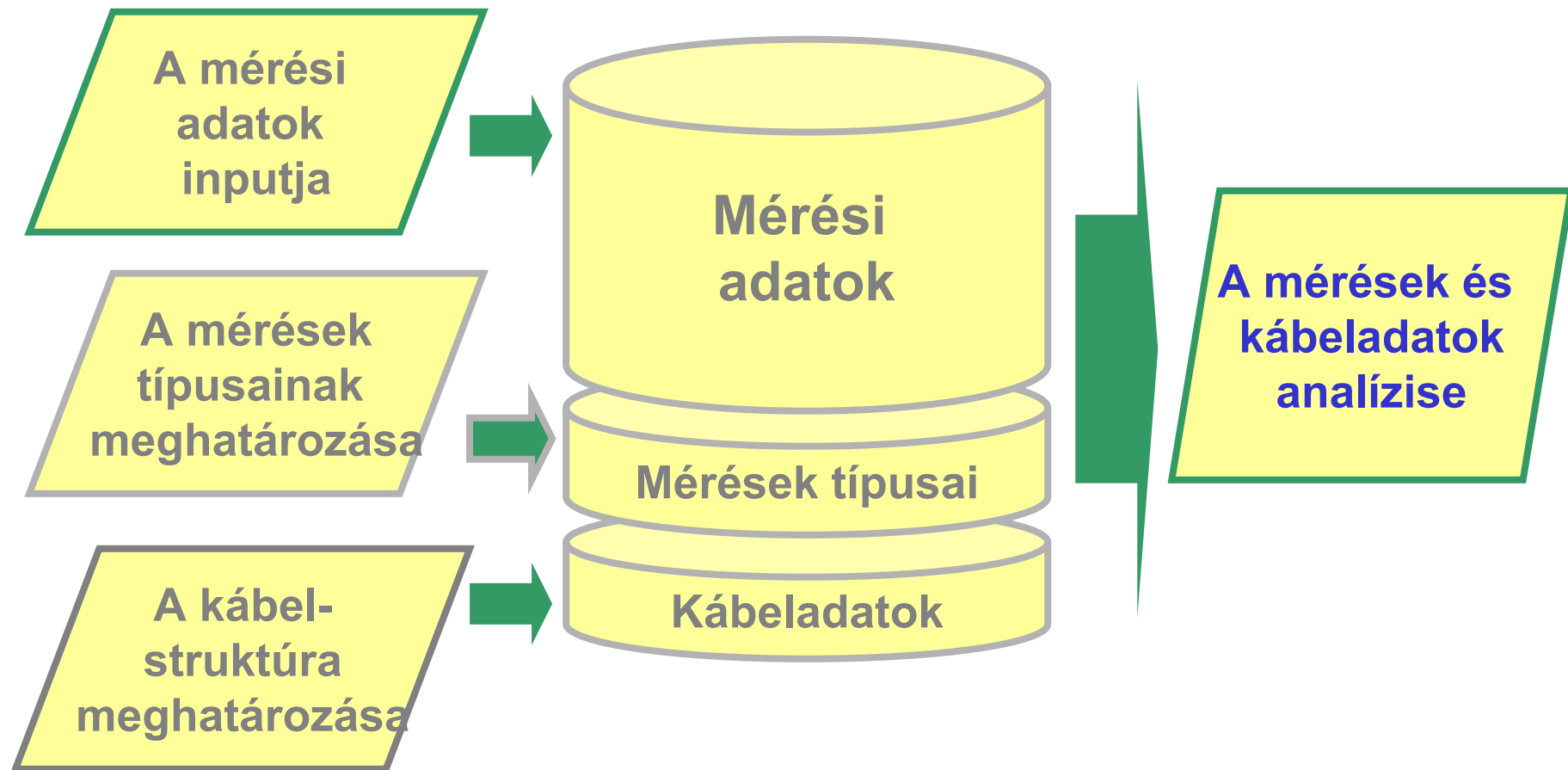
2. Adatbázis struktúra

3. Adatintegritás

4. Felhasználási módok

5. Következtetések

Az adatbázis rendszer



Felhasználási módok

- **Időanalízis**
- **Típusanalízis**
- **A specifikus populáció kiválasztása**
- **Analízis SQL és más szoftverek által**



Filter



Component



Type



Group



Help



Exit

Tree

- My selection
 - Nuon
 - 6572 - Forbo k4 / 4
 - 7885 - Forbo k15 /
 - 6570 - Forbo k2 / 4
 - 6569 - Forbo k1 / 4
 - 7652 - Middenakke
 - OSWH 670729 - A
 - 50kV Rijnsburg kab
 - Nuon
 - TestPerson

☒ Transpose

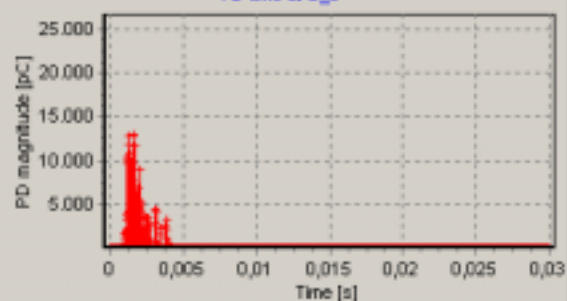
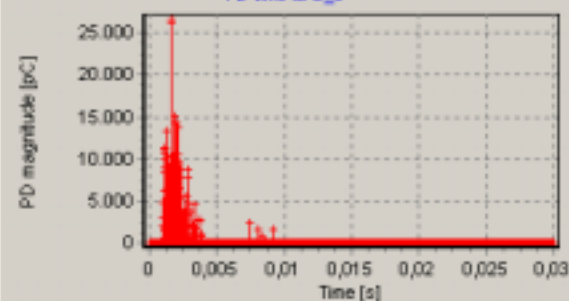
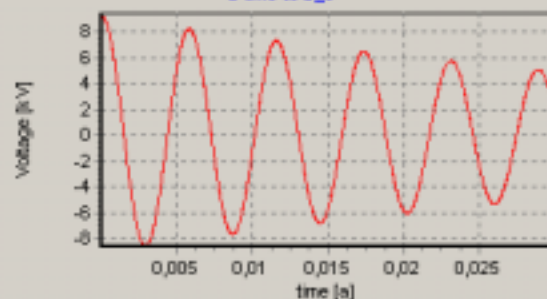
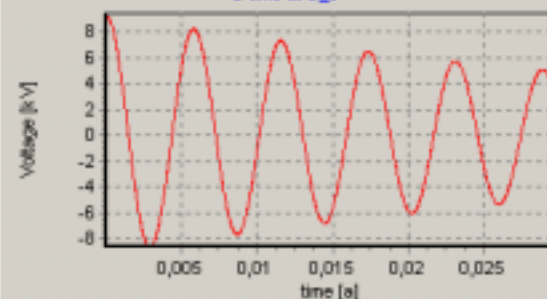
Worksheet OWTS

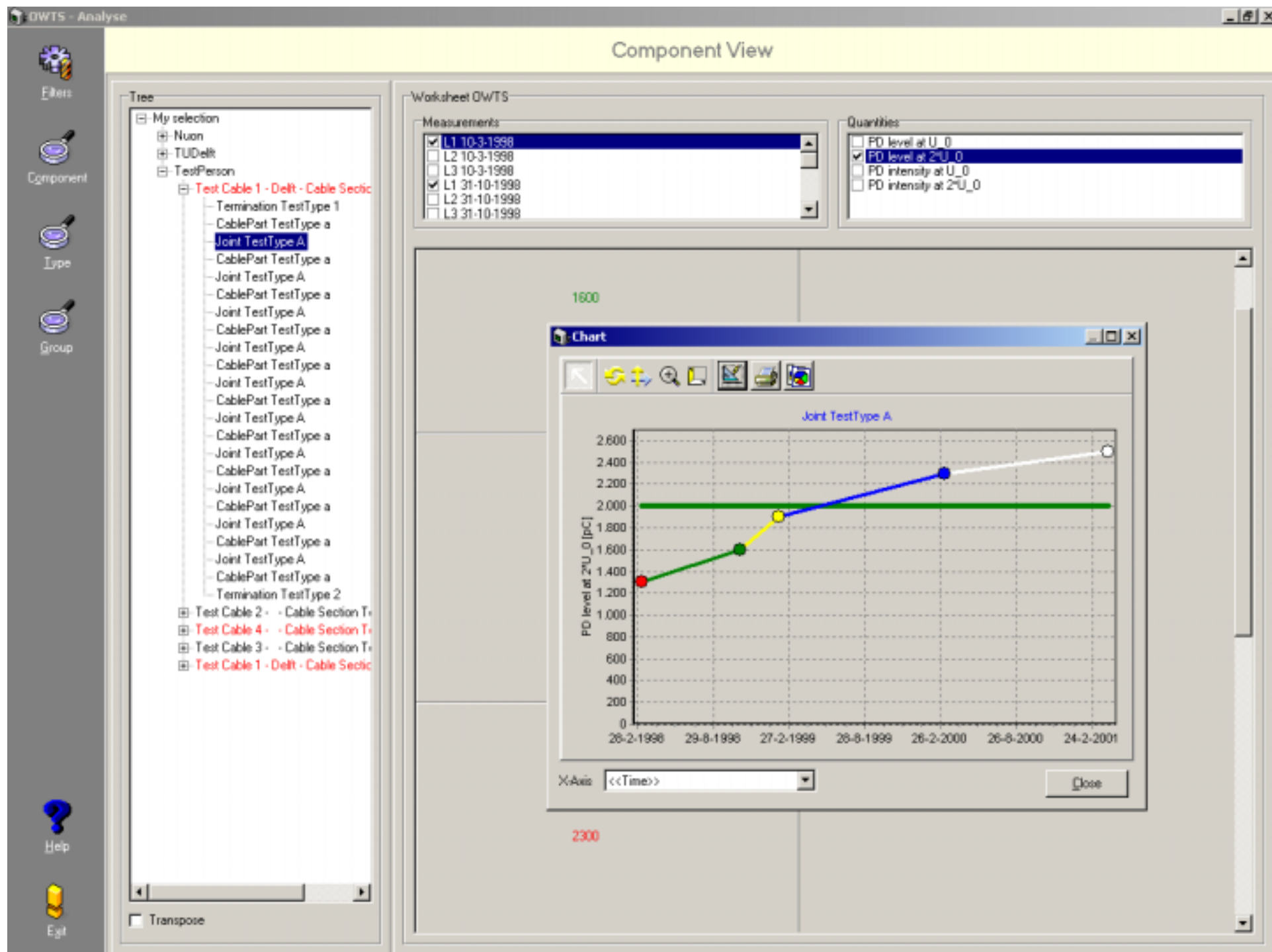
Measurements

- ☒ L1 26-2-2001 1
- ☒ L2 26-2-2001 1
- ☒ L3 26-2-2001 1
- ☐ L1 26-2-2001 2
- ☐ L2 26-2-2001 2
- ☐ L3 26-2-2001 2

Quantities

- ☐ PD-time at 2nd U₀
- ☒ U-time at U₀
- ☐ U-time at 2nd U₀
- ☐ PD-Phase-Intensity at U₀
- ☐ PD-Phase-Intensity at 2nd U₀

PD-time at U₀PD-time at U₀U-time at U₀U-time at U₀



Type View



Filter



Component



Type



Group



Help



Exit

Tree

- [-] My selection
 - [+] CableSection
 - [+] Termination
 - [+] CablePart
- [-] Joint
 - Lovitzil
 - Diemol
 - Tece
 - Unknown
 - Kabeldon
 - Nekakdiel
 - Joint TestType A
 - Joint TestType B

☐ Transpose

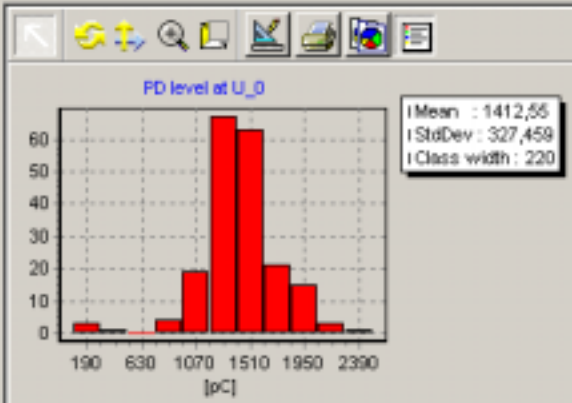
Worksheet DWTS

Measurements

- ☒ L1 10-3-1998
- ☒ L2 10-3-1998
- ☒ L3 10-3-1998
- ☒ L1 31-10-1998
- ☒ L2 31-10-1998
- ☒ L3 31-10-1998

Quantities

- ☒ PD level at U₀
- ☐ PD level at 2*U₀



Időanalízis

Két diagnosztikai mennyiség: a begyújtási feszültség és a részleges kisülés nagyságának trendje; A zöld területen a szigetelés leromlása nem kritikus; a piros terület jelzi a megnövekedett meghibásodási kockázatot.



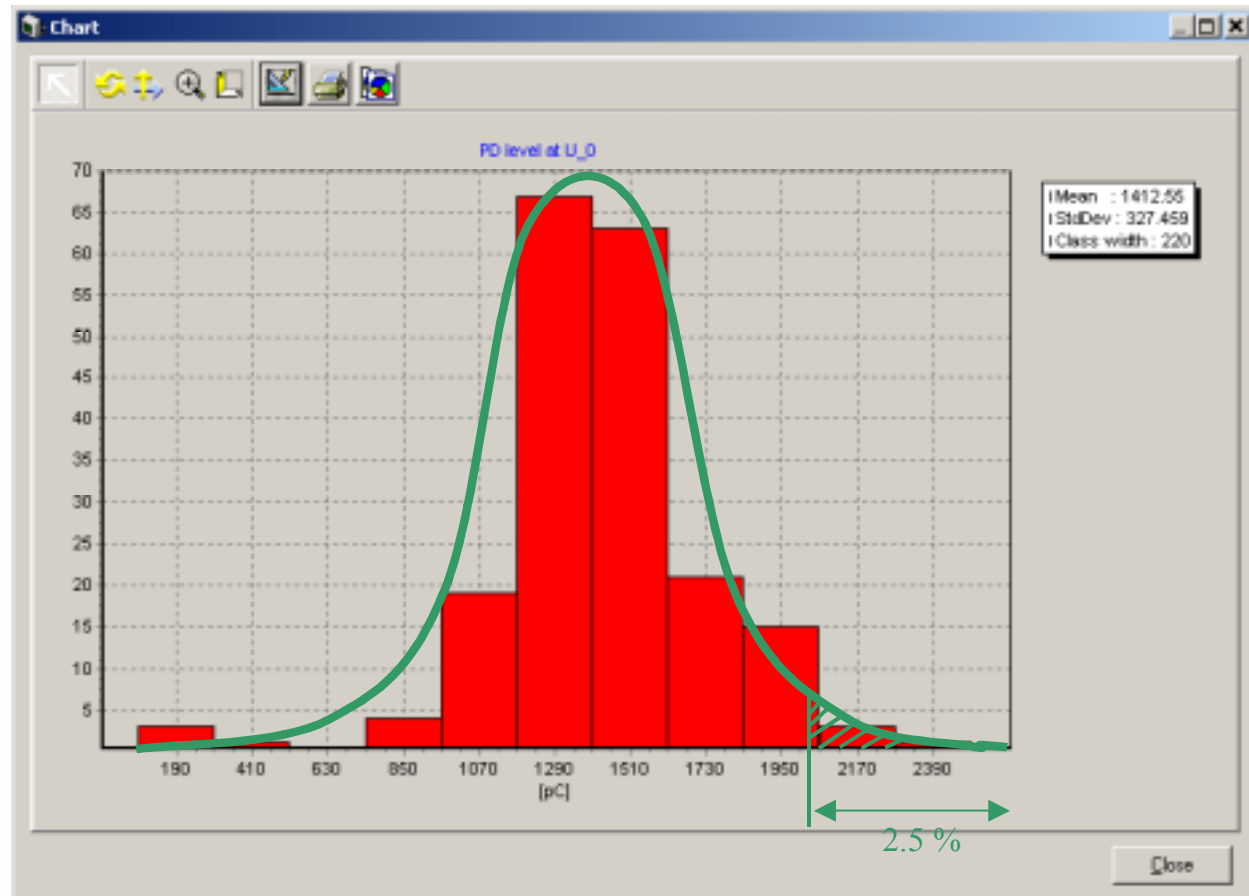
Típusanalízis

Értelmezési szabály alkotásának példája adatbázis használatával; egy típusú komponens-sorozat detektált részleges kisülés szintjeinek eloszlása.

Az A típusú
összekötők
részleges kisülés
szintje U_0 -on

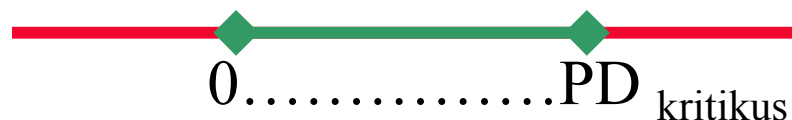
$$u = (x - \mu) / \sigma$$

$u = 1,96$ 95%-os megbízhatósági intervallumra



Normák

1 dimenziós numerikus mennyiség, intervallum



1 dimenziós többválasztásos mennyiség, a lista alkészlete

Intenzitás alacsony
Intenzitás közepes
Intenzitás magas

- A komponensek azonosításához
- normák létezhetnek az alábbiak minden kombinációjára:
 - mérés típusa,
 - komponens típusa,
 - 1dimenziós mennyiség

Filter



Filters



Component



Type



Group



Help



Exit

Filters

My selection

New Filter

Cables with high PDlevels

10 KV XLPE with possible overvoltage risk

Add

Update

Delete

Import filter

Export filter

Activate

Import data

Export results

Update Filter

Filter info

Filter name: Cables with high PDlevels

Measurement type: OWTS

Begin date: ☐ 29-6-2001 15:01:57

End date: ☐ 29-6-2001 15:01:57

Filter tree

- Cables with high PDlevels
 - Rule 1
 - CableSection : Type = GPLK
 - PD level at U_0 (CableSection) > 8000
 - Rule 2
 - CableSection : Type = XLPE
 - PD level at U_0 (CableSection) > 100

Value condition

PD level at U_0 (CableSection)

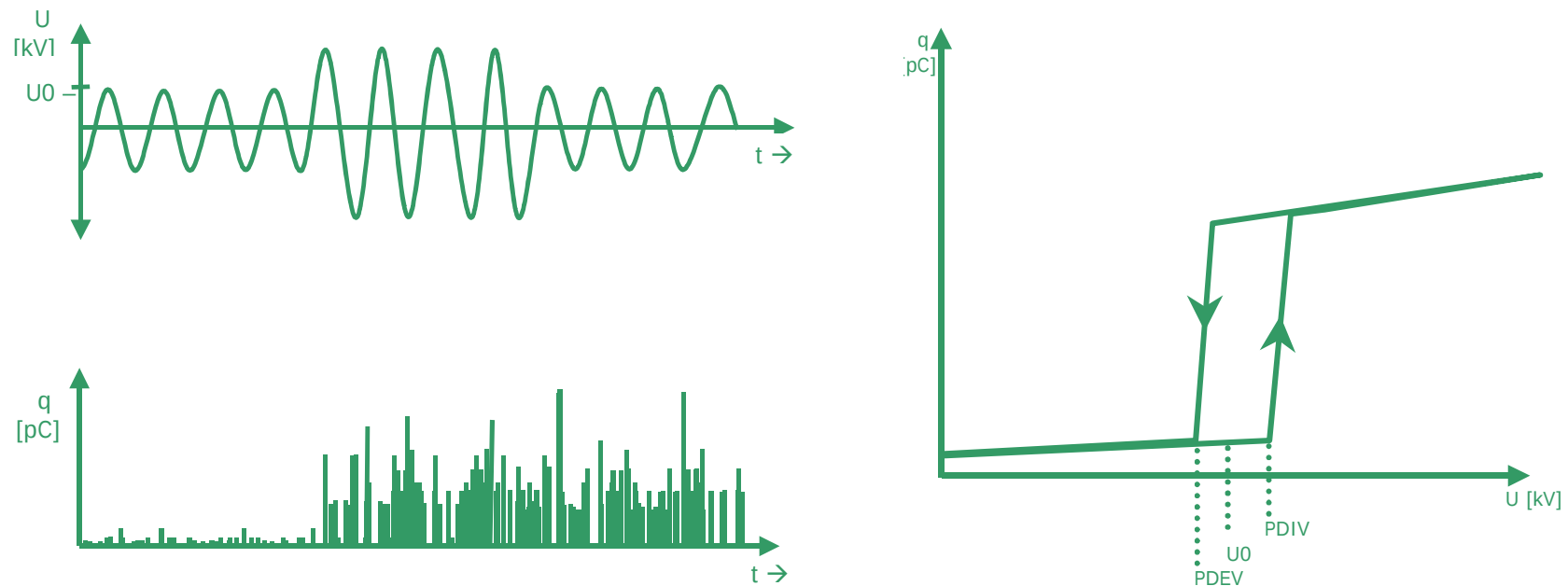
> 100 <<No quantity>>

Delete Condition

OK Cancel

Populáció kiválasztása (1)

Ideiglenes túlfeszültségek



Populáció kiválasztása

Szűrő minden olyan 10 kV-os XLPE kábel kiválasztásához , amely túlfeszültség kockázattal rendelkezik

Update Filter

Filter info

Filter name: 10 kV XLPE with possible overvoltage risk

Measurement type: OWTS

Begin date: ☐ 2-7-2001 22:10:49

End date: ☐ 2-7-2001 22:10:49

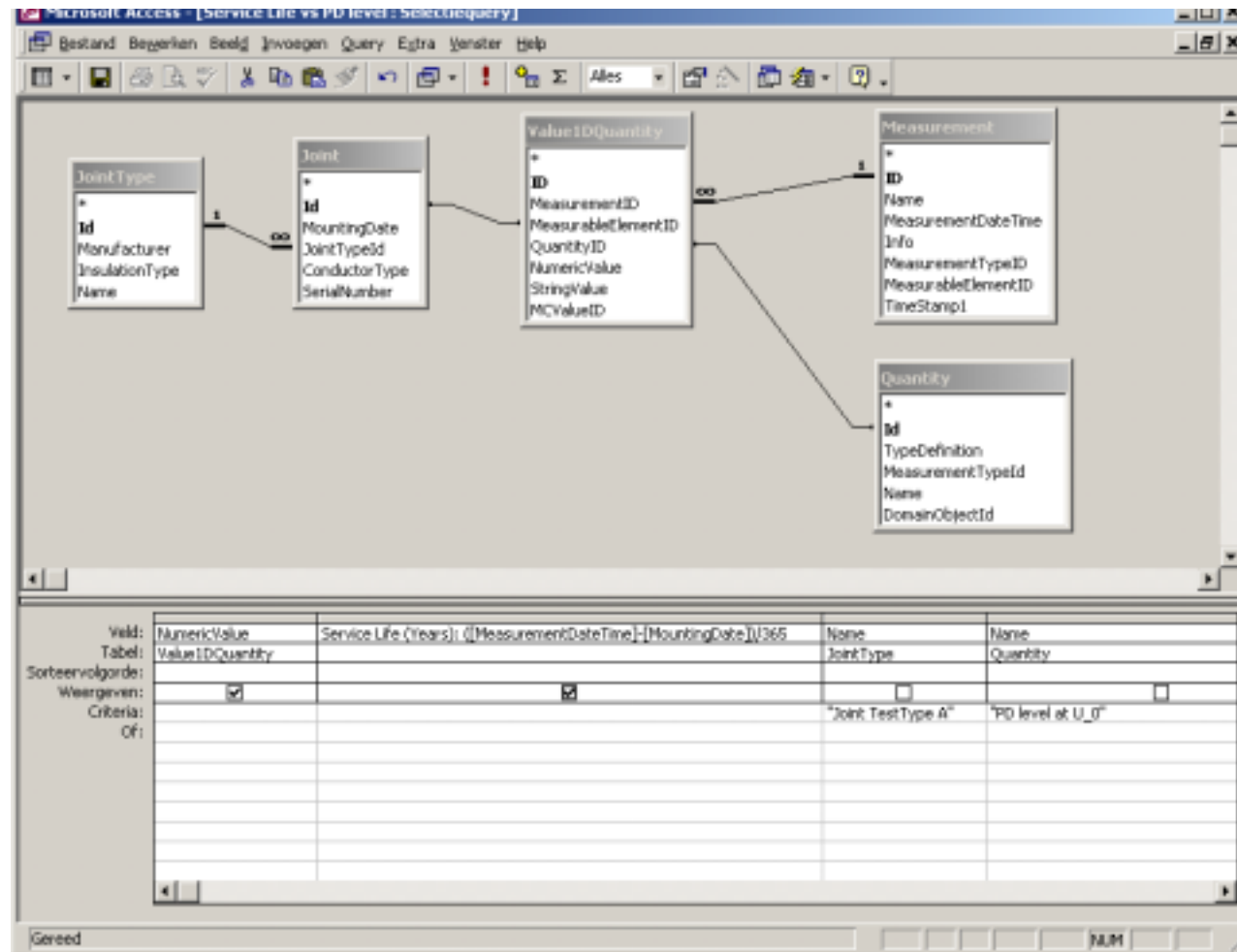
Filter tree

- [-] 10 kV XLPE with possible overvoltage risk
 - [-] Rule 1
 - CableSection : Type = XLPE
 - CableSection : VoltageClass = 10
 - PDIV (CableSection) > 10
 - PDEV (CableSection) < 10

OK Cancel

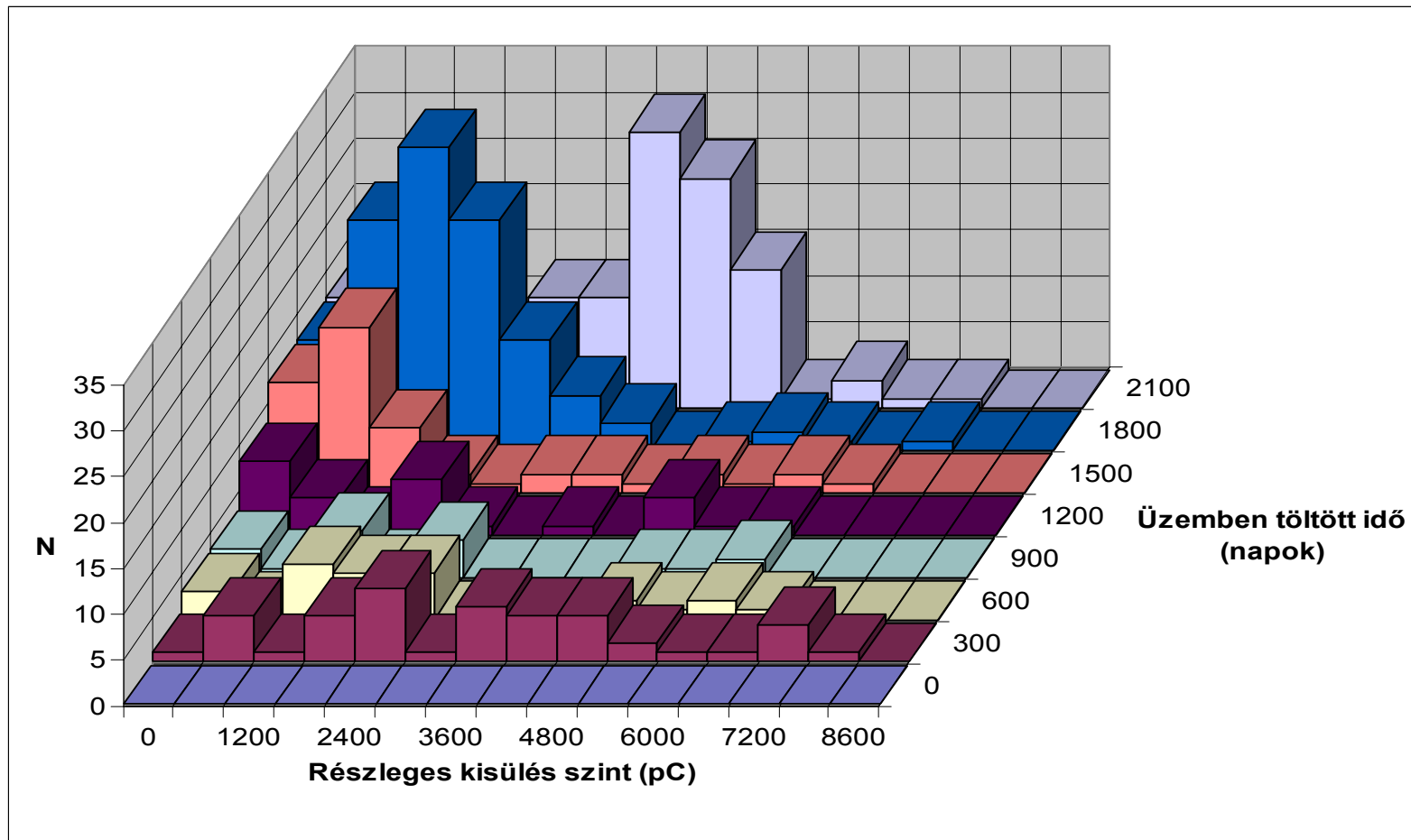
SQL analízis

MS Access lekérdezés, amely a részleges kisülés szintek adatkészletét az üzemidő függvényében állítja elő.



SQL / additional analysis

Üzemben töltött idő = Mérés dátuma - Szerelés dátuma



Adatgyűjtés és adatbázis támogatás az elosztóhálózati kábelek állapotvezérelt karbantartásához

TARTALOM

1. Általános szempontok
2. Adatbázis struktúra
3. Adatintegritás
4. Felhasználási módok

5. Következtetések

Következtetések

- Az adatbázis támogatás fontos elem a szigetelési rendszerek állapotértékelésében, pl. erősáramú kábelek esetében.
- Fejlett, roncsolásmentes módszerek használatával, a mért eredmények adatbázisban történő tárolásával és elemzésével olyan további információkat nyerhetünk, amelyek kinyerését az egyes mérések önmagukban nem teszik lehetővé.
- Ezen információk alapján kialakíthatók a felújítás vagy karbantartás különböző szintjei. Ha ezek a szintek az adatbázisban, mint *norma szintek* kerülnek alkalmazásra, könnyen kiválasztható, hogy mely komponenseken kell az állapotvezérelt karbantartási tevékenységeket elvégezni.

Datamining and Data Bases Support for CBM of Distribution Power Cables

Edward Gulski, Ben Quak
Edwin Groot (*)

(*) Delft University of Technology, HV Technology & Management, The Netherlands
(3) NUON InfraCore, The Netherlands

Data-mining and Databases Support for CBM of Distribution Power Cables

CONTENT

- 1. General aspects**
- 2. Database structure**
- 3. Data integrity**
- 4. Use Cases**
- 5. Conclusions**

Data-mining and Databases Support for CBM of Distribution Power Cables

CONTENT

1. General aspects

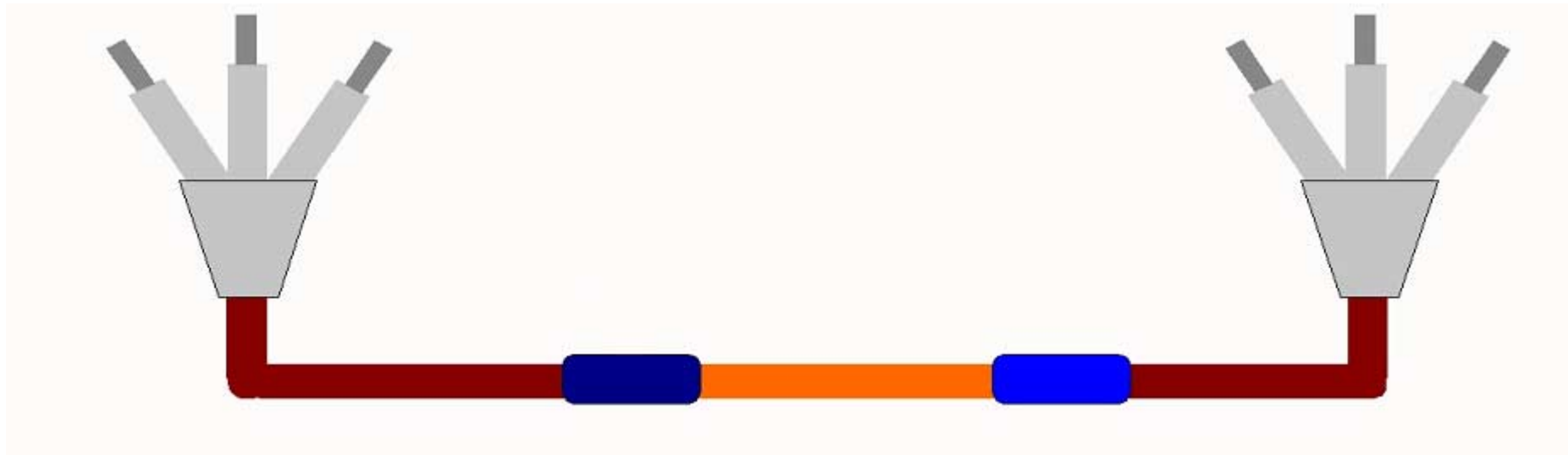
2. Database structure

3. Data integrity

4. Use Cases

5. Conclusions

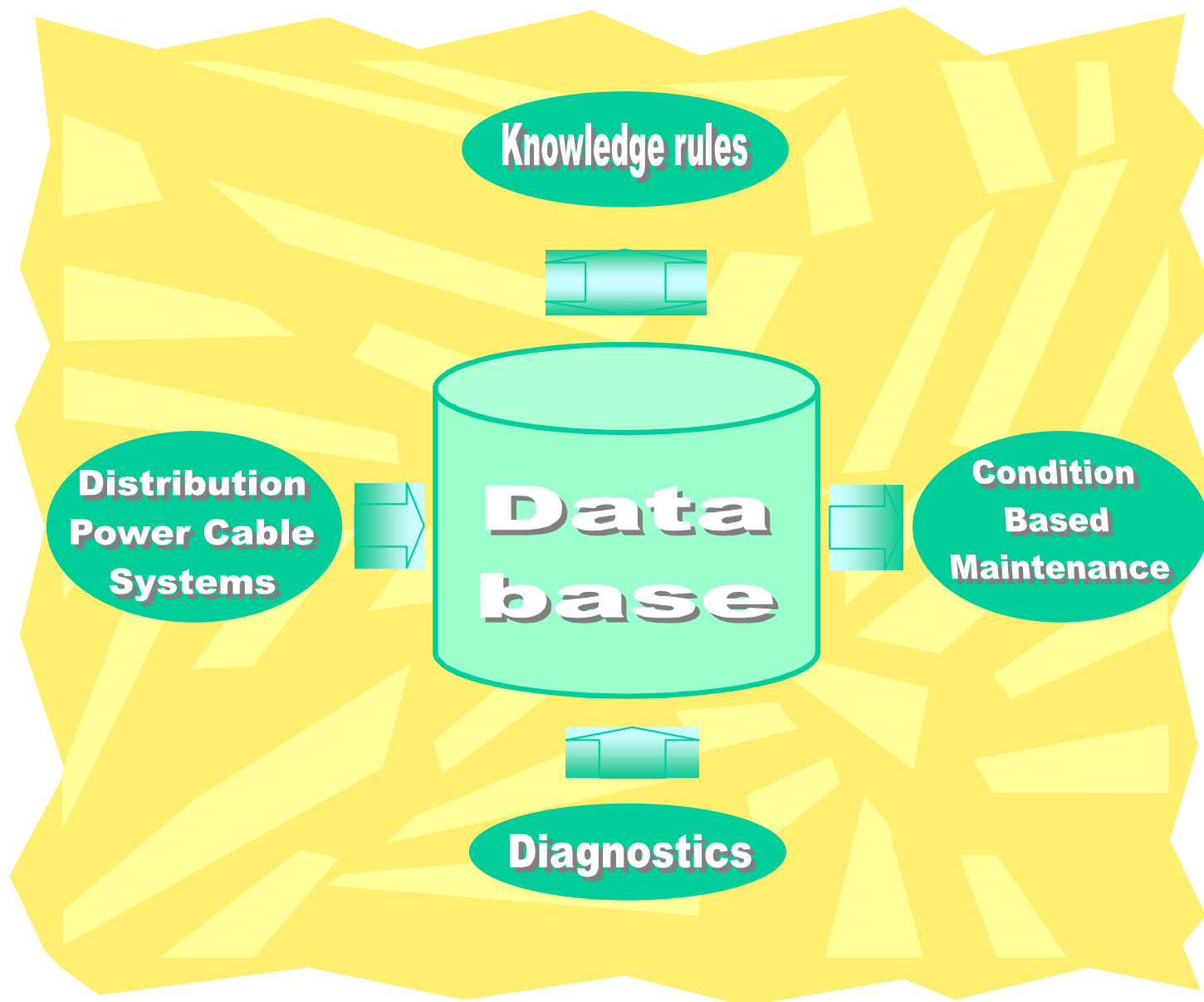
Power Cable Systems



Cable Section:

- Cable parts
- Joints
- Terminations

- Different Types
- Different Ages
- Different History



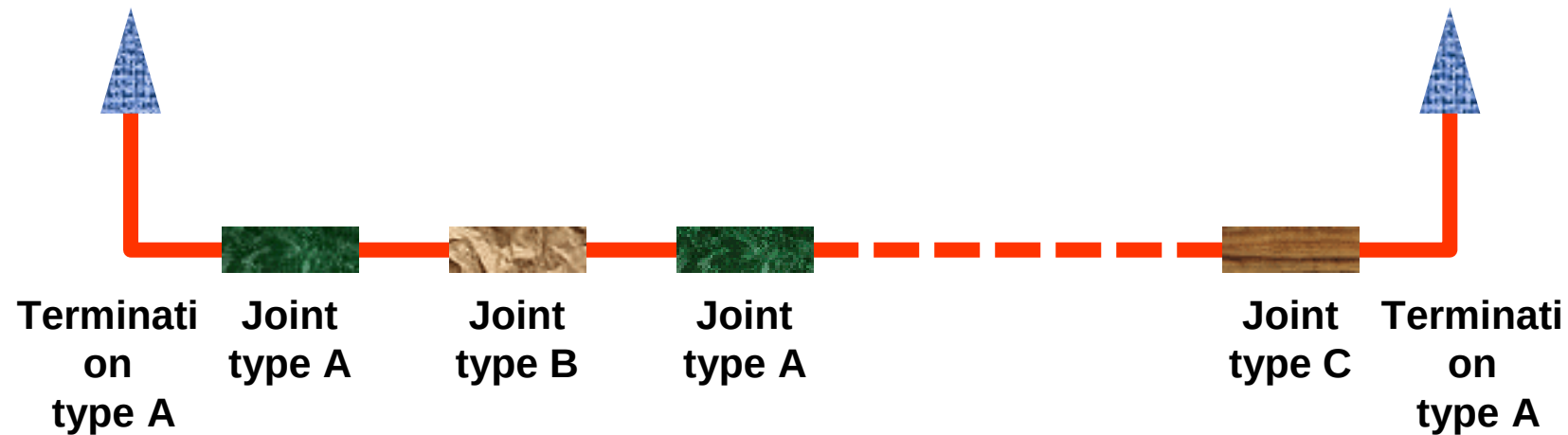
To support electrical engineers in the interpretation of diagnostics results and in the assessment of the insulation condition of power cables, linkage between the following information has to be combined and used to generate decision knowledge:

Component domain; consisting specific insulation characteristics of the cable structure; e.g. cable insulation, accessories,

Diagnostic domain; consisting type of diagnostics applied; e.g. general condition assessment, weak-spots assessment

Measuring data domain; defining specific diagnostic quantities used during condition assessment.

Data base analysis: assessing the actual insulation condition

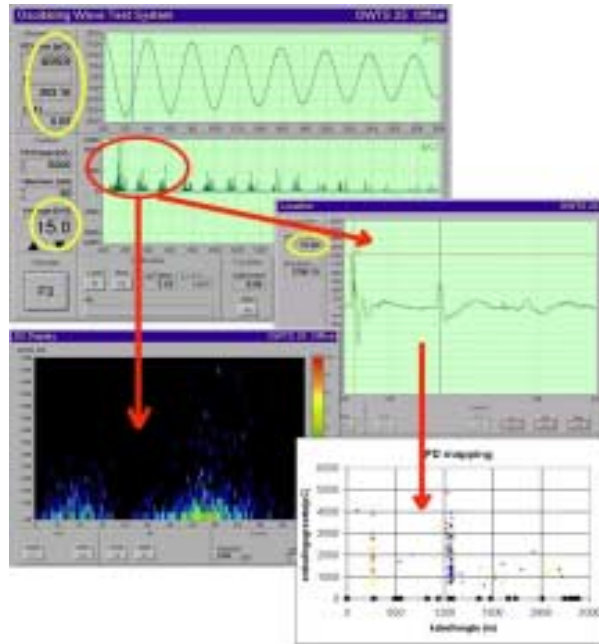


⇒ storage of measuring data;

⇒ correlation with relevant knowledge rules;

⇒ extraction of complicated information for recommendations about maintenance;

Data base analysis: PD quantities evaluation



- **PDIV;**
- **PDEV;**
- **PD level;**
- **PD intensity;**
- **PD pattern;**
- **PD mapping;**
- **Tg δ .**

Evaluation of the cable insulation condition can be analysed based on 1D, 2D & 3D measuring quantities:

- ⇒ Comparing results: PD pattern, PD mapping, $\tan \delta$, at different voltage stresses / levels;
- ⇒ Trending the differences in the terms of critical changes during service time, e.g. *trend analyze*;
- ⇒ Comparing results of similar components in the network e.g. *statistical deviation*.

Data-mining and Databases Support for CBM of Distribution Power Cables

CONTENT

1. General aspects

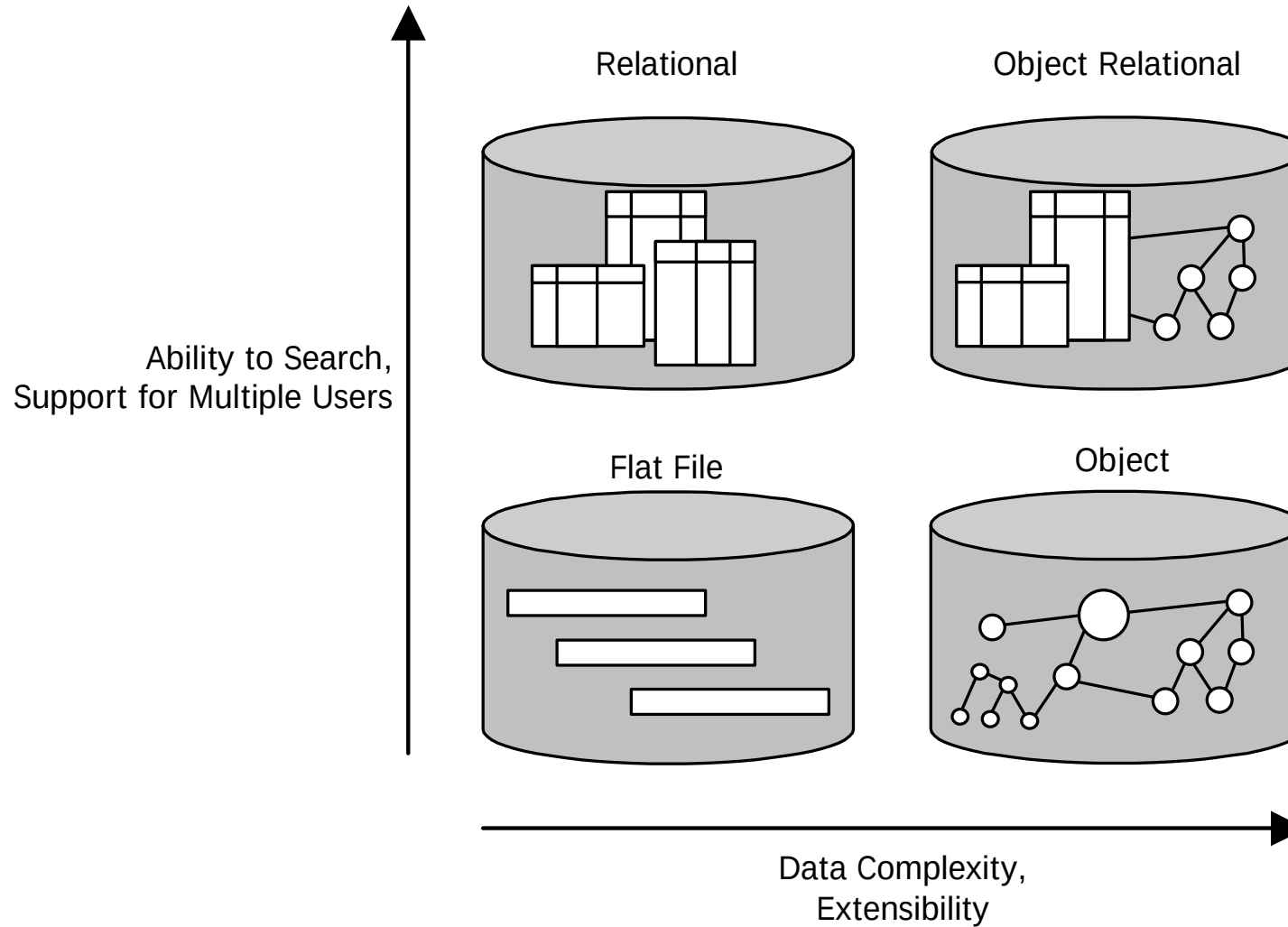
2. Database structure

3. Data integrity

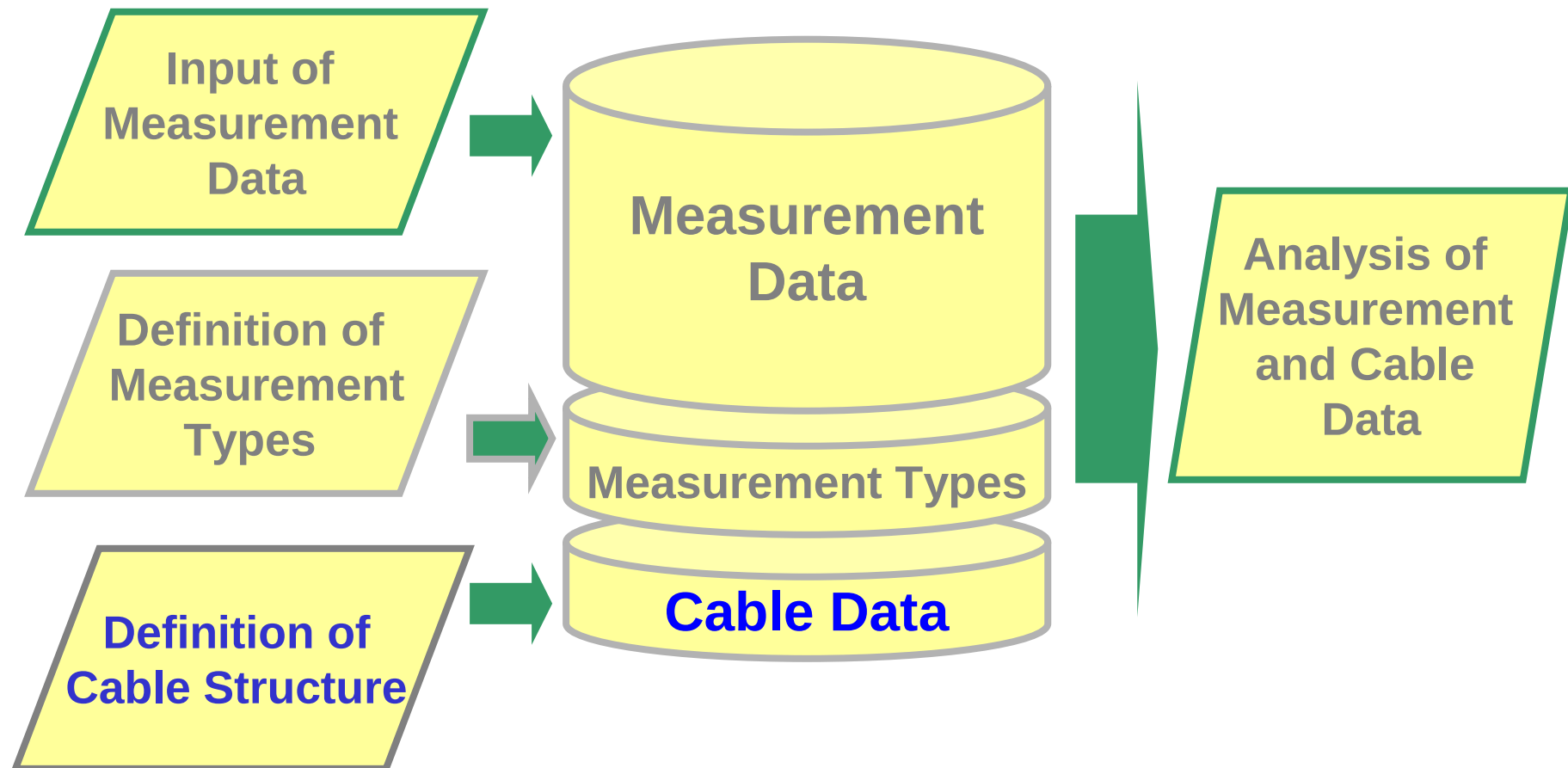
4. Use Cases

5. Conclusions

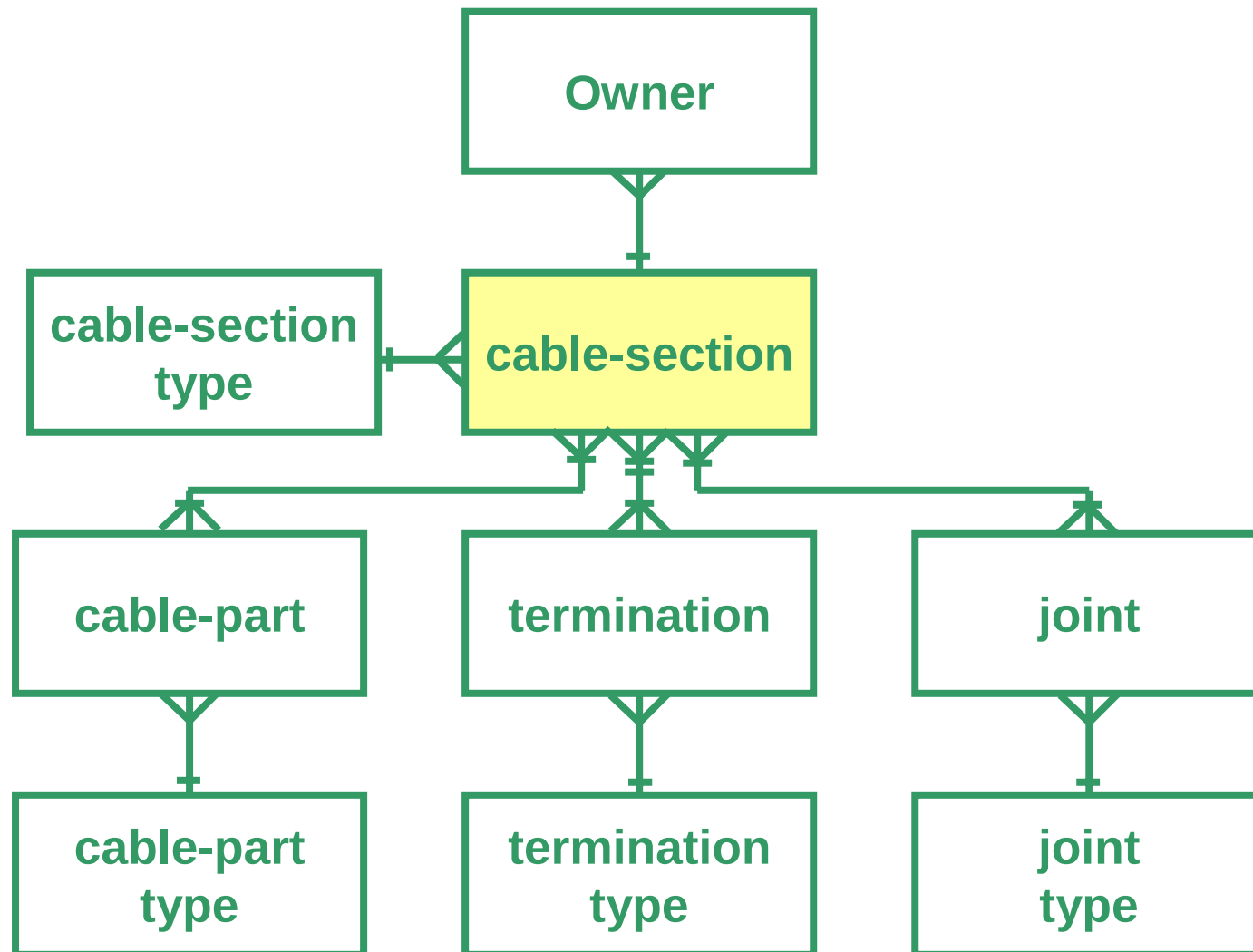
The Database System



The Database System



Cable Domain



Cable Sections



Cable Sections



Norms



Types



Persons



Help



Exit

Cable sections

6572 - Forbo k4 / 402 - 50KV Krommenie
7885 - Forbo k15 / 402 - 50kv Krommenie
6570 - Forbo k2 / 402 - 50 kV Krommenie
6569 - Forbo k1 / 402 - 50kV Krommenie
7652 - Middenakker / 406 - 50KV Purmerend KK
OSwH 670729
OSwH 288522
50kV Rijnsburg kabel veld 115 groep 7000 naar AKZO
50kV Rijnsburg kabel veld 115 groep 7000 naar AKZO
Test Cable 1
Test Cable 2
Test Cable 2
Test Cable 3

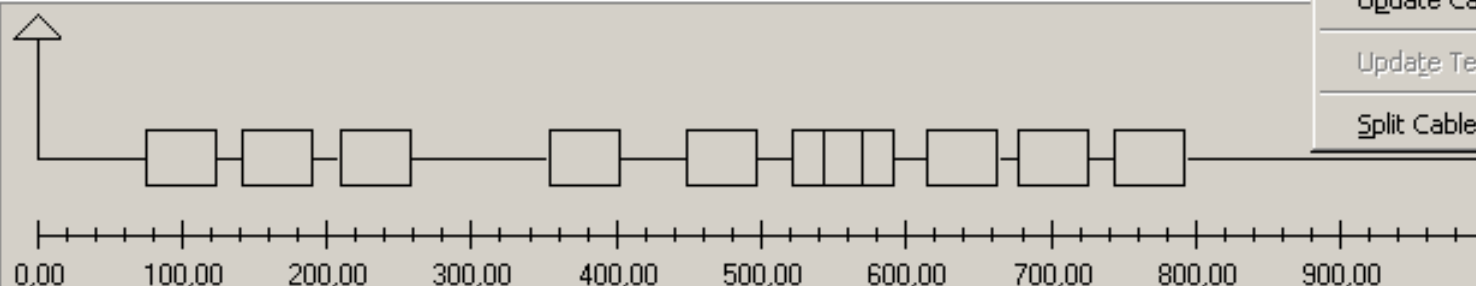
Add

Update

Join sections

Delete

Graphical



Cable section Information

Name: Test Cable 1
Type: Cable Section Test Type I
Voltage Class: 10
City: Delft
Owner: TestPerson
Section number: 9676068
Load: Unknown
Earthing faults: None
Soil conditions: Unknown
History:

Add joint

Update Joint

Delete Joint

Update Cable part

Update Termination

Split Cable section



Cable Sections



Cable Sections



Norms



Types



Persons



Help



Exit

Cable sections

6572 - Forbo k4 / 402 - 50KV Krommenie
7885 - Forbo k15 / 402 - 50kv Krommenie
6570 - Forbo k2 / 402 - 50 kV Krommenie
6569 - Forbo k1 / 402 - 50kV Krommenie

7652 - Middenakker /
OSwH 670729
OSwH 288522
50kV Rijnsburg kabel
50kV Rijnsburg kabel
Test Cable 2
Test Cable 4
Test Cable 3
Test Cable 1

Add joint

Joint type

Conductor type

Serial number

Mounting date

Distance left cable part ending m

Distance right cable part ending m

Distance end of cable section m

OK

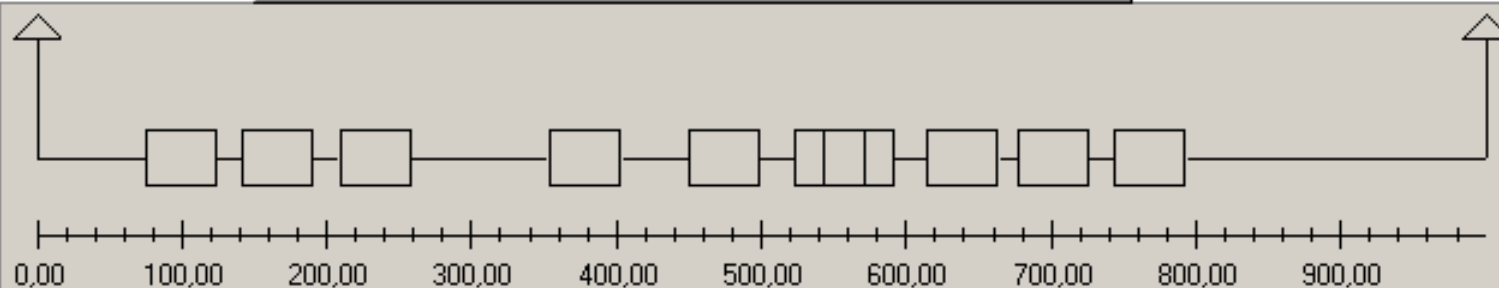
Cancel

Cable section Information

Name

Type

Graphical



Types

Cable Sections

Norms



Types



Persons



Help



Exit

Cable component types | Cable section types

Cable part types

TKF 150 AL
TKF 95 CU
NKF 95 CU
Unknown 95 CU
VOHW 95 CU
TKF 240 AL
AA150AL
AA95AI

Add

Update

Delete

Name

TKF 150 AL

Manufacturer

TKF

Insulation type

Paper Oil

Conductor type

150AL

Joint types

Lovisil
Oliemof
Tece
Unknown
Kabeldon
Nekaldiet
Joint TestType A
Joint TestType B

Add

Update

Delete

Name

Manufacturer

Insulation type

Termination types

Coq
Magnefix
Capitole
Onbekend ES D 47
Unknown
Termination TestType 1
Termination TestType 2

Add

Update

Delete

Name

Manufacturer

Insulation type

Persons



Cable Sections



Norms



Types



Persons



Help



Exit

Persons

Nuon
Benjamin Quak
TUDelft
Ben Quak
TestPerson
TestPerson number 2

Name TestPerson number 2

Address Mekelweg 4

Zip 2628CD

City Delft

Phone 0152789111

Info TestPerson number 2 is een inspector voor test doeleinden.

☐ Customer ☒ Inspector

Add

Update

Delete

Norms


Cable Sections

Norms



Types



Persons



Help



Exit

Quantities and Component types

Measurement type OWTS

Component

- ☐ Termination
☒ Joint
☐ Cable part
☐ Cable section

Component type

Tece
Unknown
Kabeldon
Nekaldiet
Joint TestType A
Joint TestType B

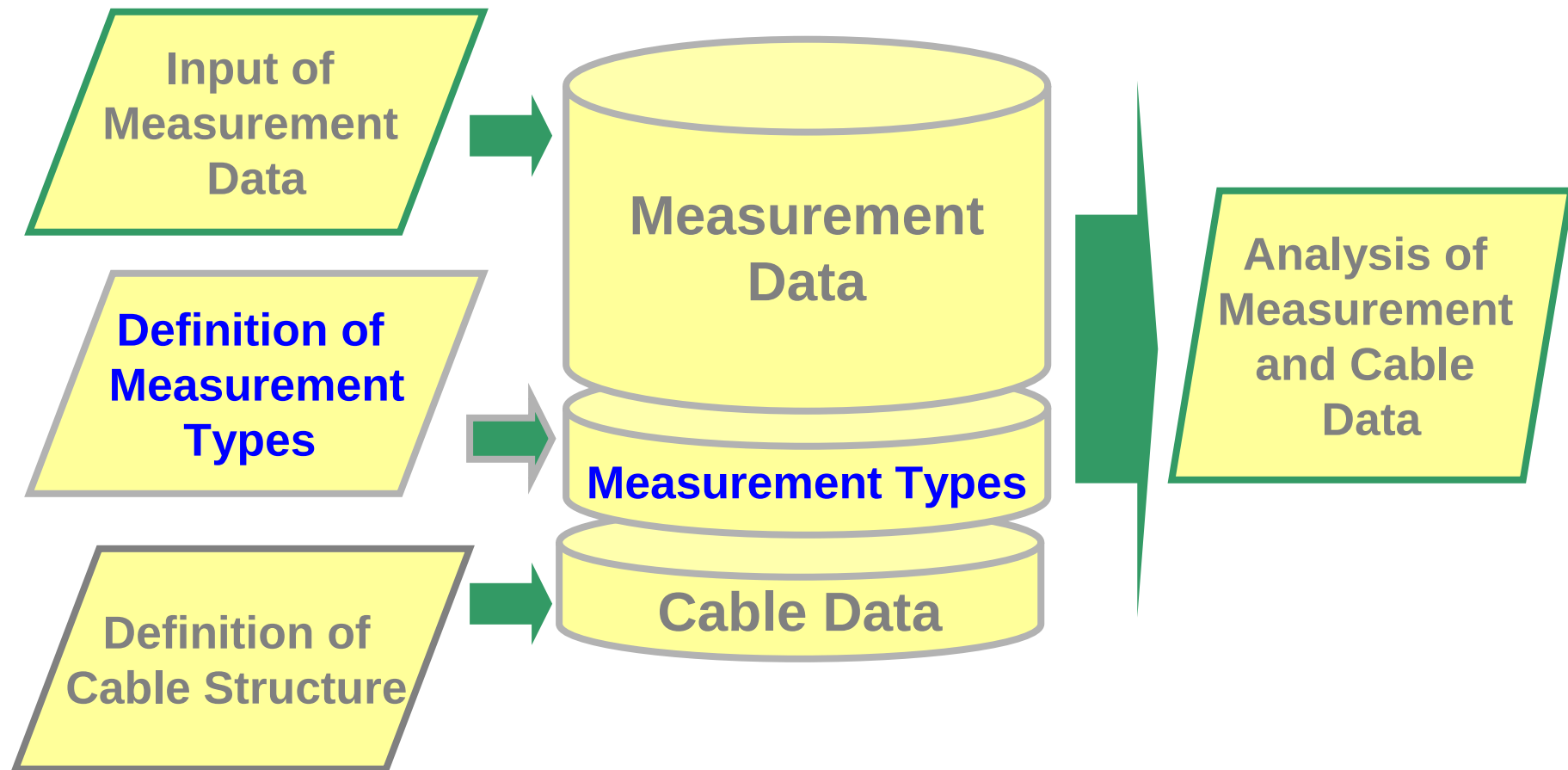
Quantity

PD level at U_0
PD level at 2*U_0
PD intensity at U_0
PD intensity at 2*U_0

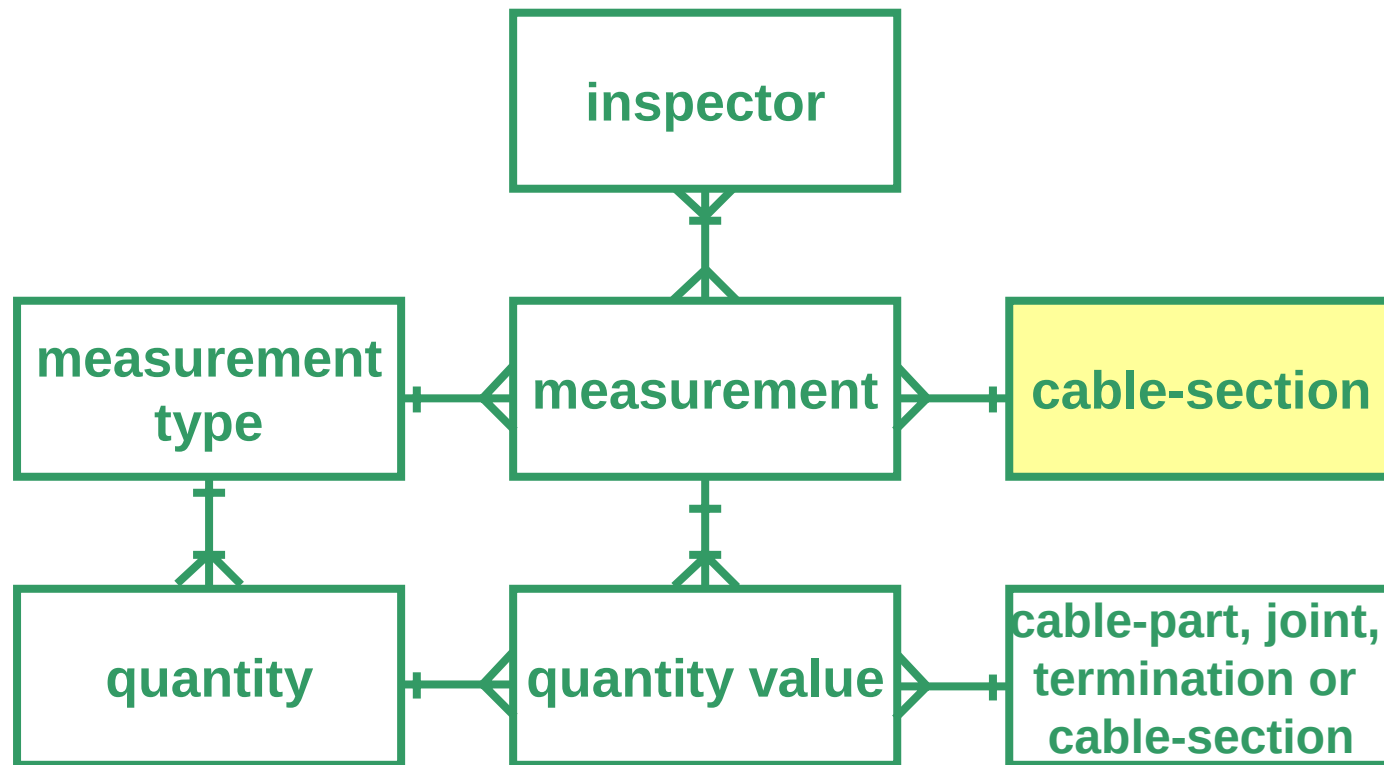
Norm (numerical)

Minimum value Common value Maximum value

The Database System



Measurement Domain





Types



Choices



Help



Exit

Measurement Types

Measurement type

OWTS

New

Delete

1D Quantities

2D Quantities

3D Quantities

Comment

PDIV

PDEV

PD level at U_0

PD level at U_0

PD level at U_0

PD level at U_0

PD level at 2*U_0

PD level at 2*U_0

PD level at 2*U_0

PD level at 2*U_0

Tg Delta at U_0

Tg Delta at 2*U_0

PD intensity at U_0

PD intensity at U_0

PD intensity at U_0

PD intensity at U_0

PD intensity at 2*U_0

PD intensity at 2*U_0

PD intensity at 2*U_0

PD intensity at 2*U_0

Condition

Update 1D quantity

Name

PD level at 2*U_0

Type

Numerical

Numerical

Unit

pC

Low value

0,00000

High value

1000000,00000

Apply to

CableSection

OK

Cancel

Add

Update

Delete



Types



Choices



Help



Exit

Measurement Types

Measurement type

OWTS

New

Delete

1D Quantities

2D Quantities

3D Quantities

PD Mapping at U_0

PD Mapping at 2*U_0

PD-time at U_0

PD-time at 2*U_0

U-time at U_0

U-time at 2*U_0

Name PD Mapping at U_0

Number of lines to skip

3

Data column

1

First dimension/column

Axis ☒ X ☐ Y

Axis label Cable Length

Unit m

Second dimension/column

Axis ☐ X ☒ Y

Axis label PD magnitude

Unit pC

Graph type ☐ Line ☒ Scatter ☐ Spike

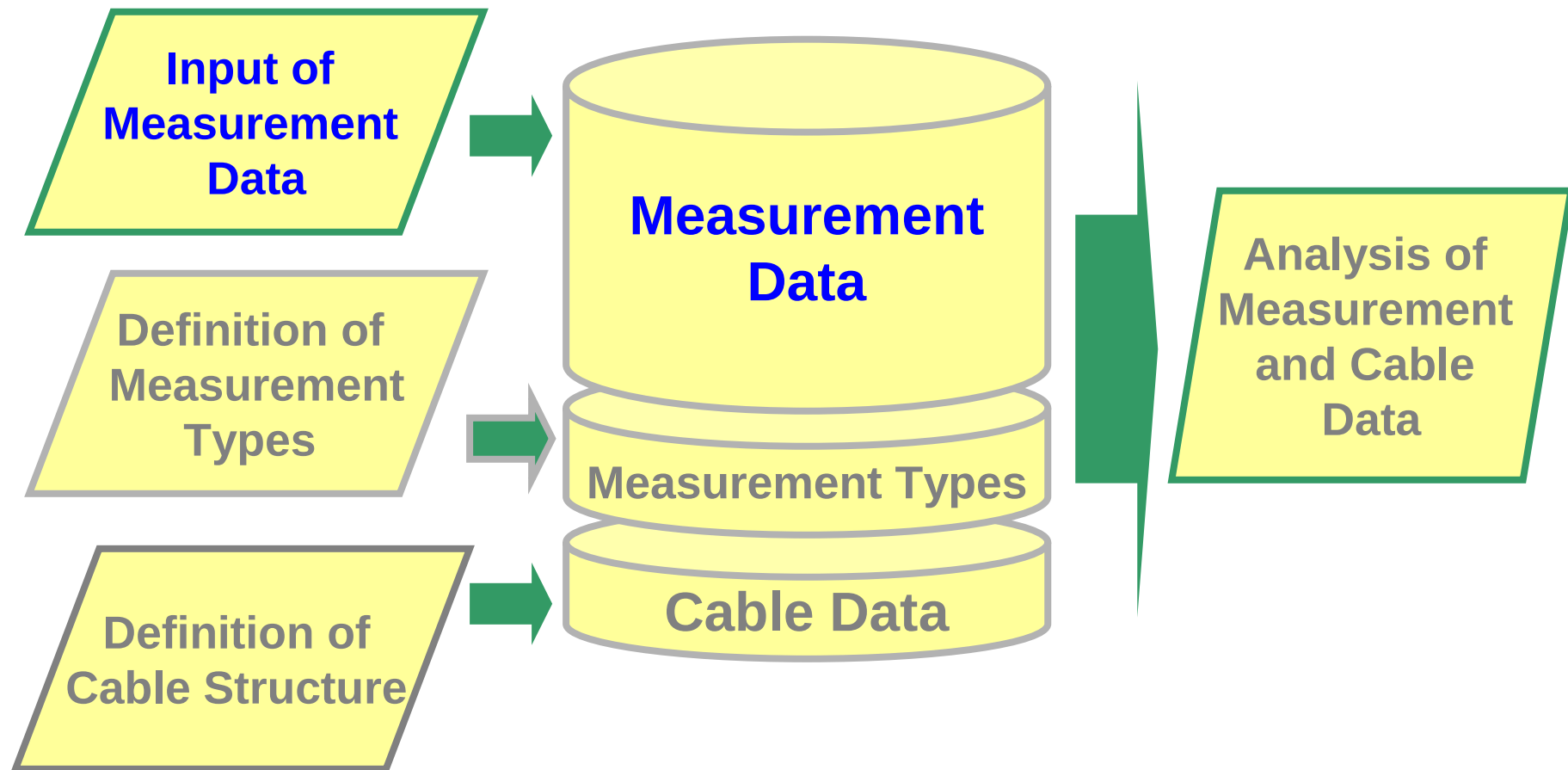
Apply to CableSection

Add

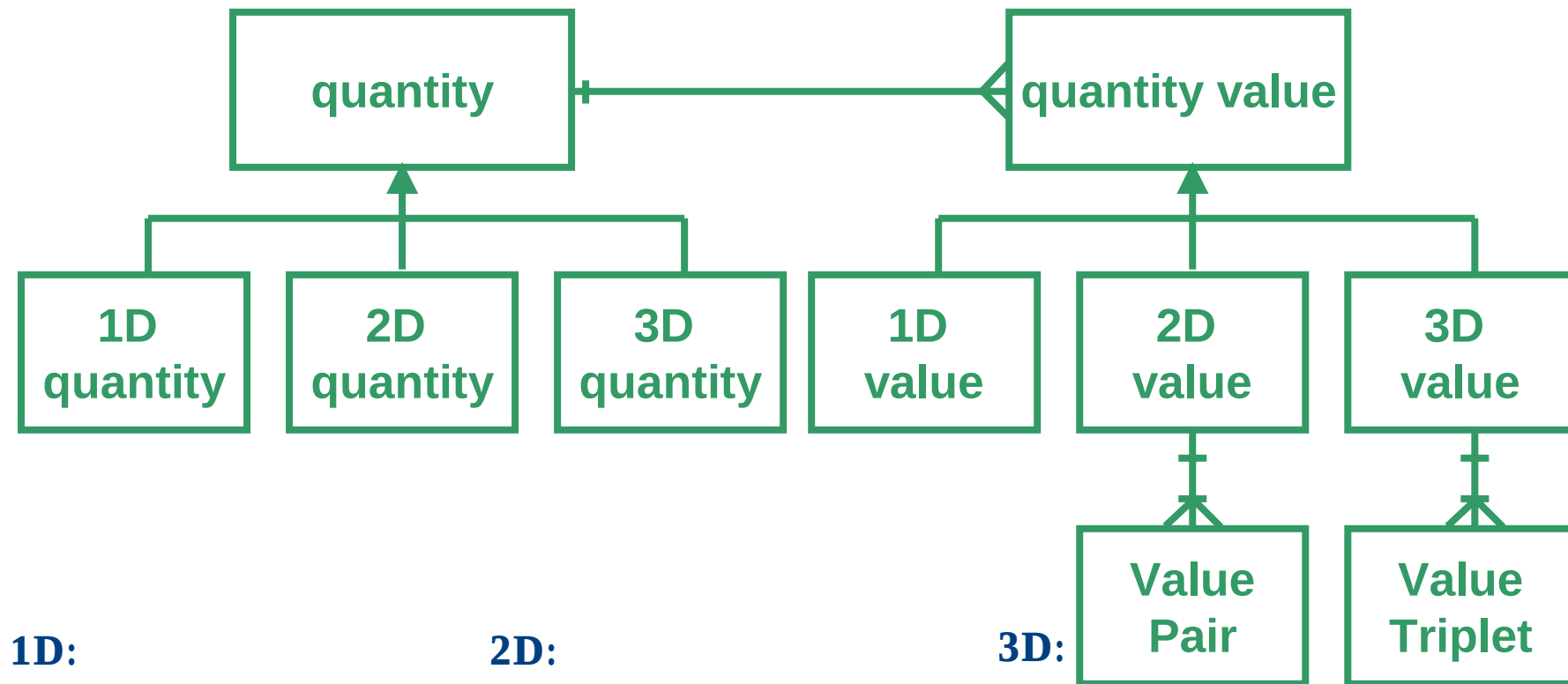
Update

Delete

The Database System



Quantity Domain



1D:

Numeric Value

Text Value

Multiple-Choice Value

2D:

List of Numeric Pairs

3D:

List of Numeric Triplets



Selection



Measurement



Help



Exit

Selection

Measurement type

OWTS

Component

- ☒ CableSection
 - 6572 - Forbo k4 / 402 - 50KV Krommenie - Krommenie - GPLK
 - 7885 - Forbo k15 / 402 - 50kv Krommenie - Krommenie - GPLK
 - 6570 - Forbo k2 / 402 - 50 kV Krommenie - Krommenie - GPLK
 - 6569 - Forbo k1 / 402 - 50kV Krommenie - Krommenie - GPLK
 - 7652 - Middenakker / 406 - 50KV Purmerend KK - - GPLK
 - OSWH 670729 - Amsterdam - GPLK
 - OSWH 288522 - Amsterdam - GPLK
 - 50kV Rijnsburg kabel veld 115 groep 7000 naar AKZO - - GPLK
 - 50kV Rijnsburg kabel veld 115 groep 7000 naar AKZO - - GPLK
 - Test Cable 1 - Delft - Cable Section Test Type I**
 - Test Cable 2 - - Cable Section Test Type I
 - Test Cable 4 - - Cable Section Test Type I
 - Test Cable 3 - - Cable Section Test Type I
 - Test Cable 1 - Delft - Cable Section Test Type I



Selection



Measurement



Help



Exit

Measurement

Measurements

L1 10-3-1998

L2 10-3-1998

L3 10-3-1998

L1 31-10-1998

L2 31-10-1998

L3 31-10-1998

L1 02-02-1999

L2 02-02-1999

L3 02-02-1999

L1 05-03-2000

L2 05-03-2000

L3 05-03-2000

L1 03-04-2001

L2 03-04-2001

L3 03-04-2001

Add

Copy

Update

Delete

Measurement Info

Name

L1 10-3-1998

Date

10-3-1998 13:50:33

Inspectors

TestPerson number 2

Measurement

Update measurement



Information | Quantities

Measurement Info

Name

L1 30-11-1999

Date

30-11-1999

0:00:00

Inspectors

- ☒ Benjamin Quak
- ☐ Ben Quak
- ☐ TestPerson number 2

Select All

Deselect All

Invert Selection

OK

Cancel



Selection



Measurement



Help



Exit

Measurement

Update measurement



Information

Quantities

Components

[-] 6572 - Forbo k4 / 402

[-] CablePart

- TKF 150 AL
- TKF 95 CU
- TKF 150 AL
- TKF 95 CU
- NKF 95 CU
- TKF 150 AL
- TKF 95 CU
- TKF 150 AL
- TKF 95 CU
- TKF 95 CU

[-] Joint

- Lovisil
- Lovisil
- Lovisil
- Oliemof
- Tece
- Tece
- Lovisil
- Lovisil
- Lovisil

[-] Termination

Quantities

1D Quantities

2D Quantities

3D Quantities

Comment

PDIV

kV

PDEV

kV

PD level at U₀

pC

PD level at 2*U₀

pC

Tg Delta at U₀Tg Delta at 2*U₀PD intensity at U₀PD intensity at 2*U₀

Condition

PD level at PDIV

pC

OK

Cancel

Selection

Measure



Help



Exit

Measurement

Update measurement



Information

Quantities

Components

[-] 6572 - Forbo k4 / 402

[-] CablePart

- TKF 150 AL
- TKF 95 CU
- TKF 150 AL
- TKF 95 CU
- NKF 95 CU
- TKF 150 AL
- TKF 95 CU
- TKF 150 AL
- TKF 95 CU
- TKF 95 CU

[-] Joint

Lovisil

Lovisil

Lovisil

Oliemof

Tece

Tece

Lovisil

Lovisil

Lovisil

[+] Termination

Quantities

1D Quantities

2D Quantities

3D Quantities

PD level at U_0 pCPD level at 2*U_0 pC

PD intensity at U_0 <<< No value >>> ▼

PD intensity at 2*U_0 Low ▼

OK

Cancel

Selection

Measure



Help



Exit

Measurement

Update measurement



Information

Quantities

Components

[-] 6572 - Forbo k4 / 402

[-] CablePart

... TKF 150 AL

... TKF 95 CU

... TKF 150 AL

... TKF 95 CU

... NKF 95 CU

... TKF 150 AL

... TKF 95 CU

... TKF 150 AL

... TKF 95 CU

... TKF 95 CU

[-] Joint

... Lovisil

... Lovisil

... Lovisil

... Oliemof

... Tece

... Tece

... Lovisil

... Lovisil

... Lovisil

[+] Termination

Quantities

1D Quantities

2D Quantities

3D Quantities

PD Mapping at U_0

PD Mapping at 2*U_0

PD-time at U_0

PD-time at 2*U_0

U-time at U_0

U-time at 2*U_0

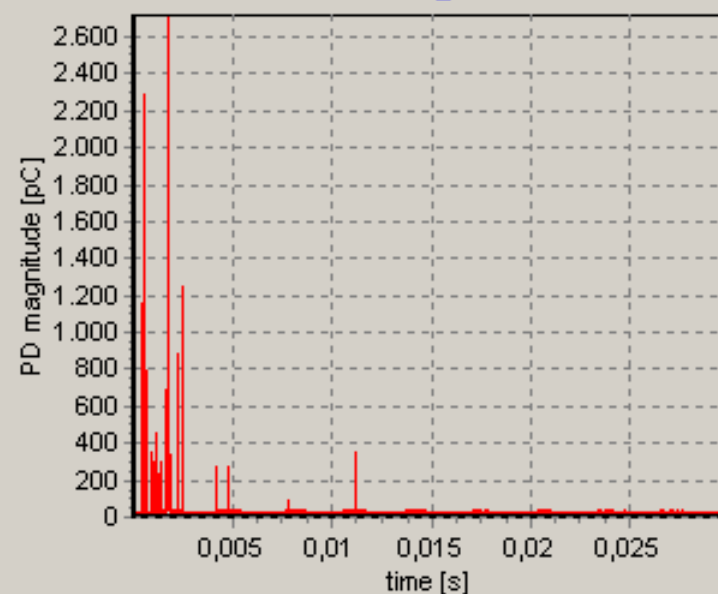
Import

Delete

Table



PD-time at 2*U_0



OK

Cancel

Selection

Measure



Help



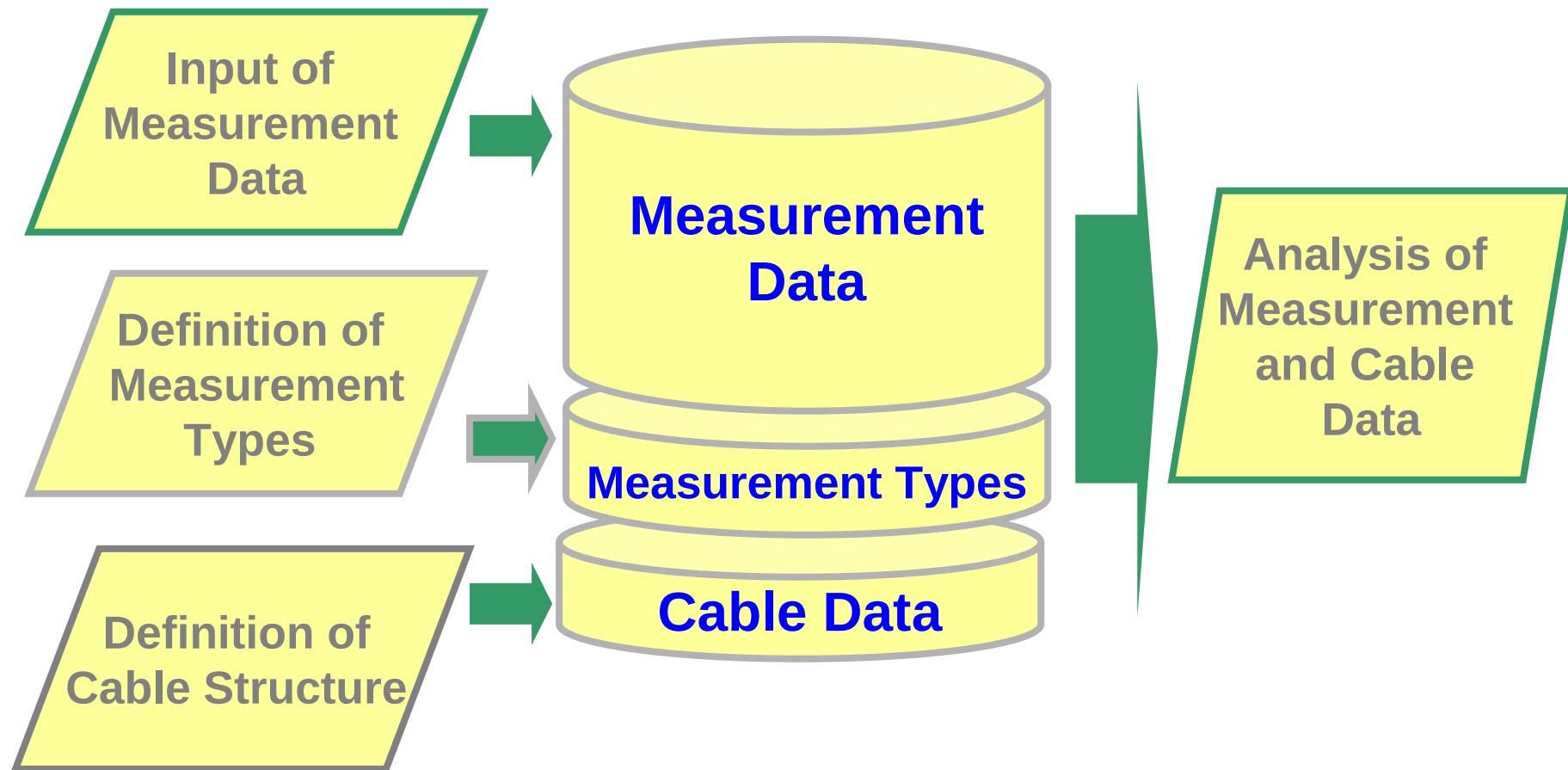
Exit

Data-mining and Databases Support for CBM of Distribution Power Cables

CONTENT

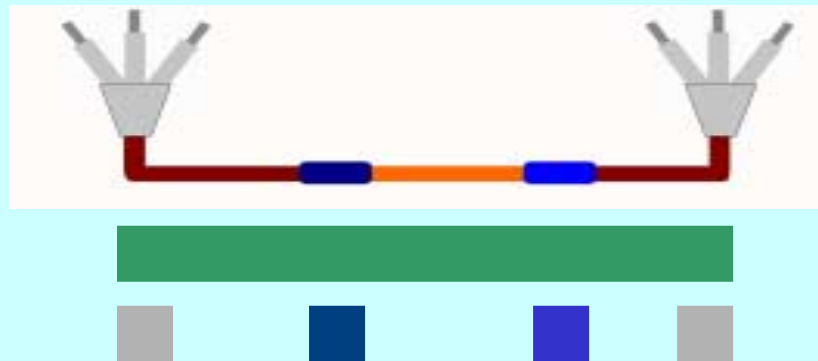
1. General aspects
2. Database structure
- 3. Data integrity**
4. Use Cases
5. Conclusions

The Database System

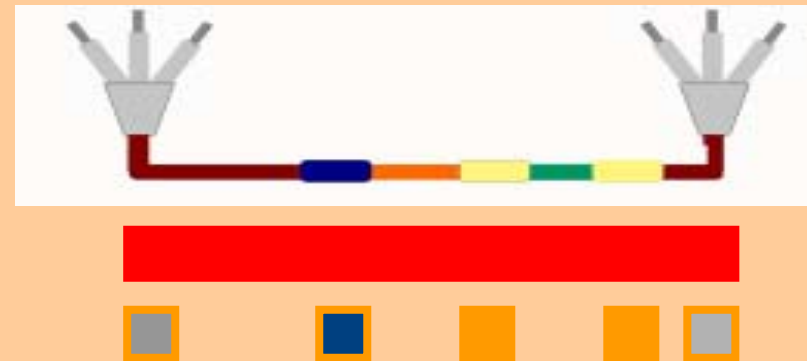


Data integrity

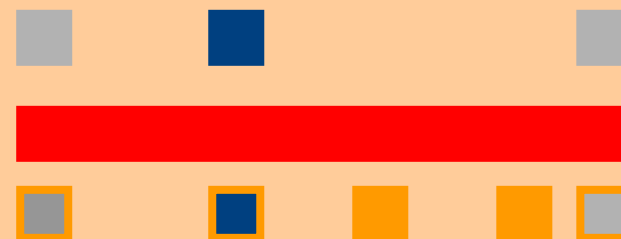
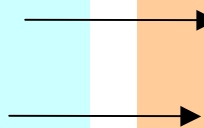
Situation before repair



Situation after repair



Valid Measurement Data

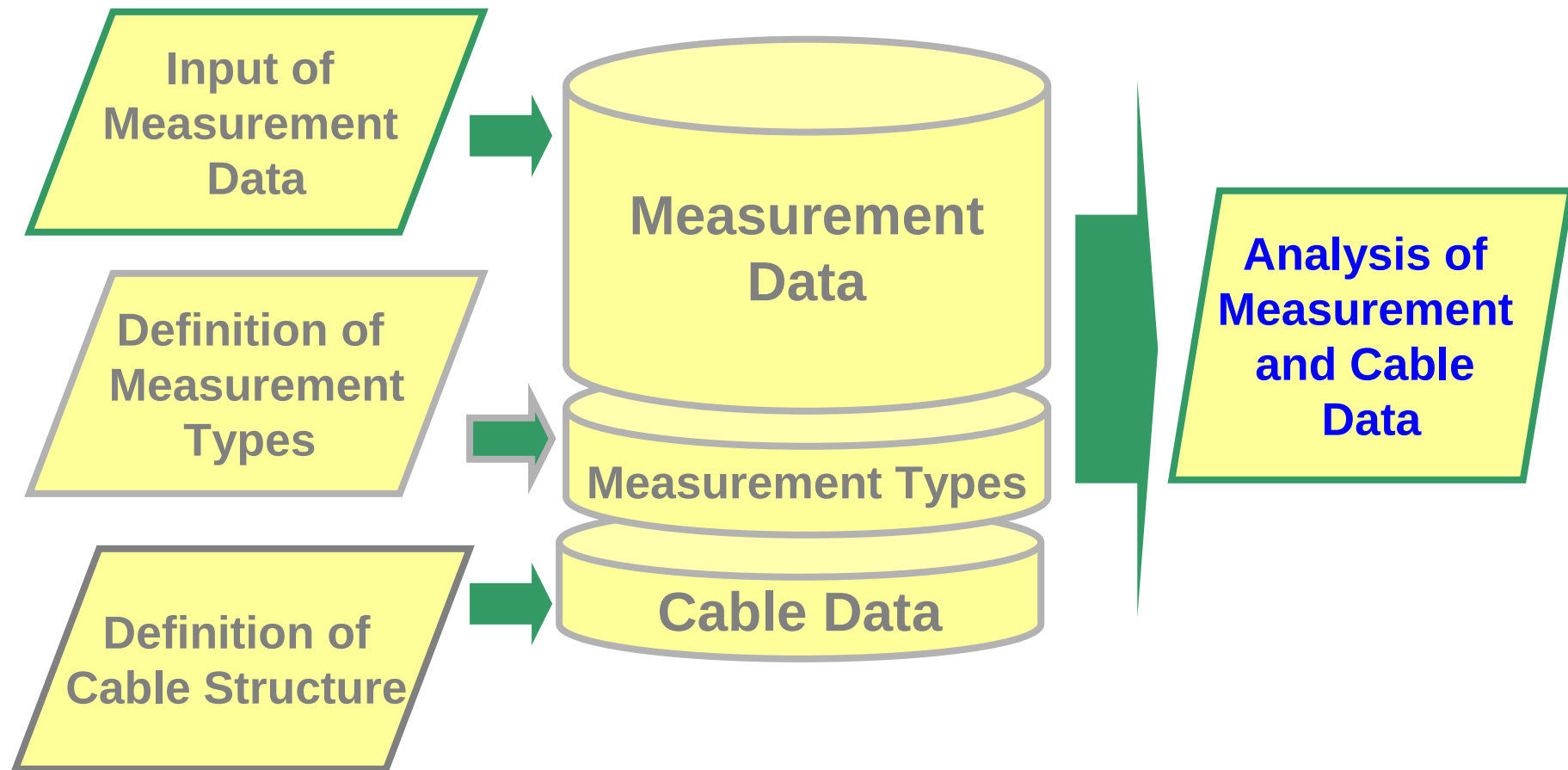


Data-mining and Databases Support for CBM of Distribution Power Cables

CONTENT

1. General aspects
2. Database structure
3. Data integrity
- 4. Use Cases**
5. Conclusions

The Database System



Use Cases

- **Time Analysis**
- **Type Analysis**
- **Selection of specific populations**
- **Analysis through SQL and additional software**



Filter



Component



Type



Group



Help



Exit

Tree

- My selection
 - Nuon
 - 6572 - Forbo k4 / 4
 - 7885 - Forbo k15 /
 - 6570 - Forbo k2 / 4
 - 6569 - Forbo k1 / 4
 - 7652 - Middenakke
 - OSWH 670729 - A
 - 50kV Rijnsburg kab
 - Nuon
 - TestPerson

☒ Transpose

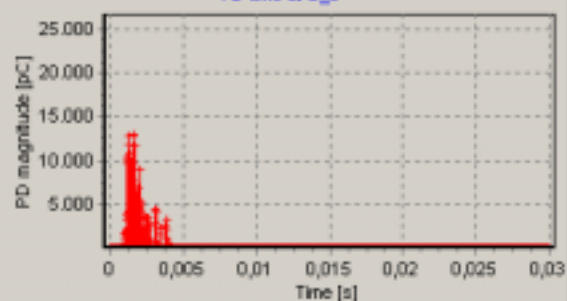
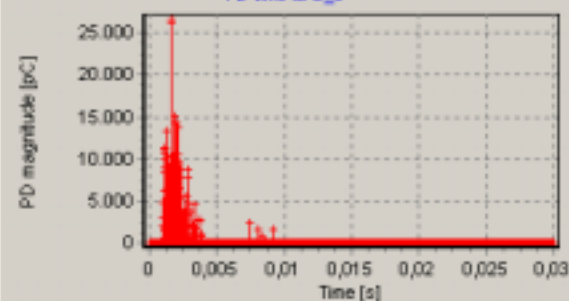
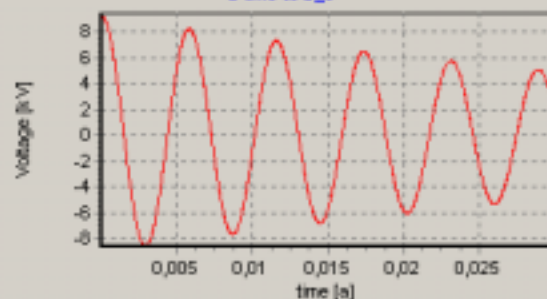
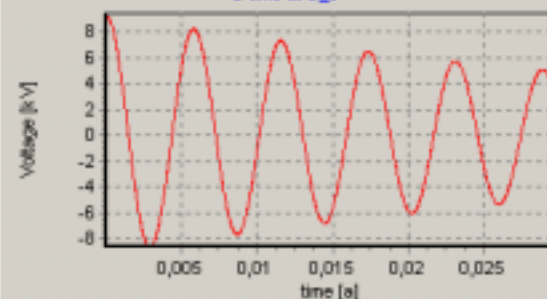
Worksheet OWTS

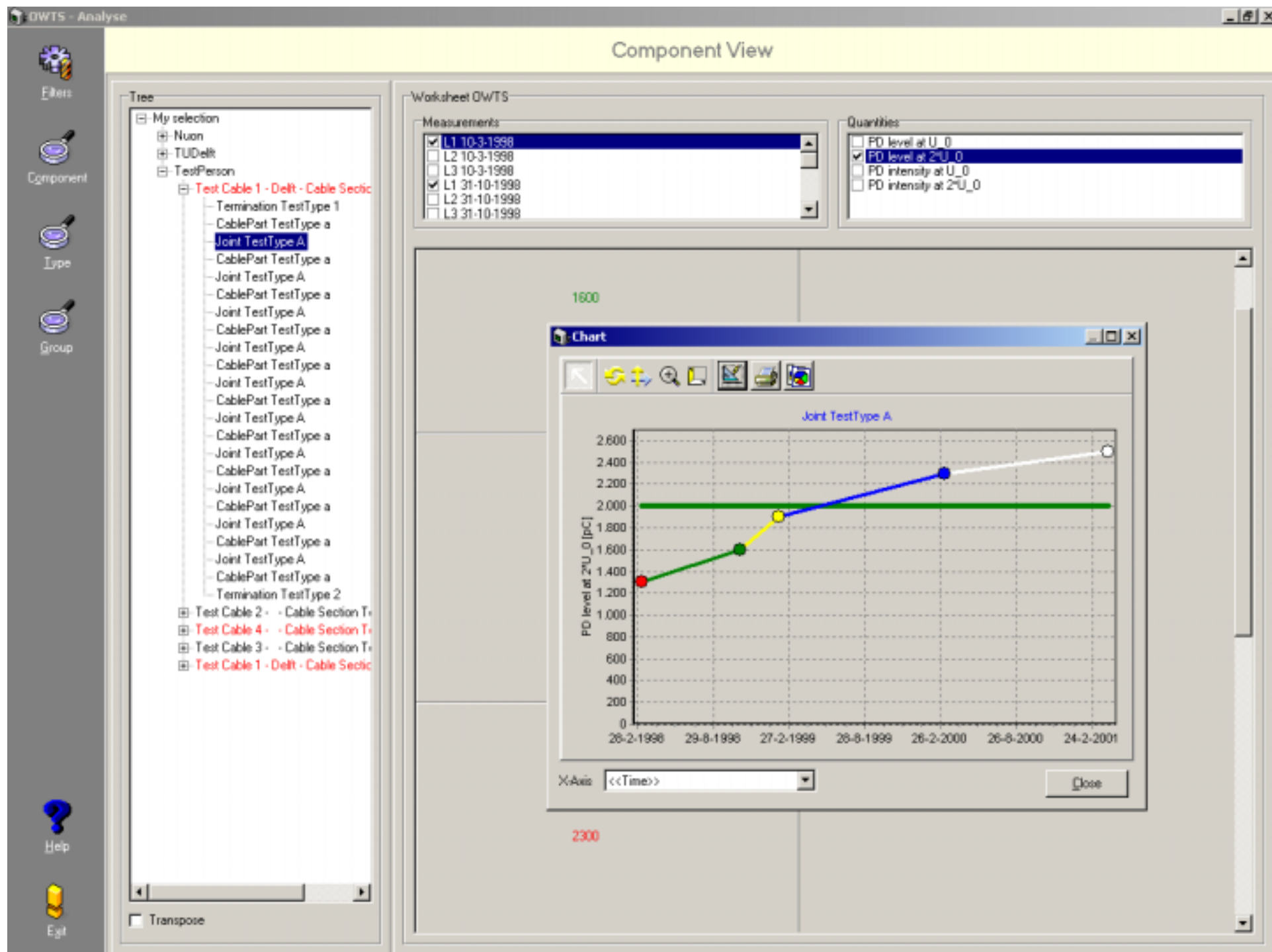
Measurements

- ☒ L1 26-2-2001 1
- ☒ L2 26-2-2001 1
- ☒ L3 26-2-2001 1
- ☐ L1 26-2-2001 2
- ☐ L2 26-2-2001 2
- ☐ L3 26-2-2001 2

Quantities

- ☐ PD-time at 2nd U₀
- ☒ U-time at U₀
- ☐ U-time at 2nd U₀
- ☐ PD-Phase-Intensity at U₀
- ☐ PD-Phase-Intensity at 2nd U₀

PD-time at U₀PD-time at U₀U-time at U₀U-time at U₀



Type View



Filter



Component



Type



Group



Help



Exit

Tree

- [-] My selection
 - [+] CableSection
 - [+] Termination
 - [+] CablePart
- [-] Joint
 - Lovitzil
 - Diemol
 - Tece
 - Unknown
 - Kabeldon
 - Nekakdiel
 - Joint TestType A
 - Joint TestType B

☐ Transpose

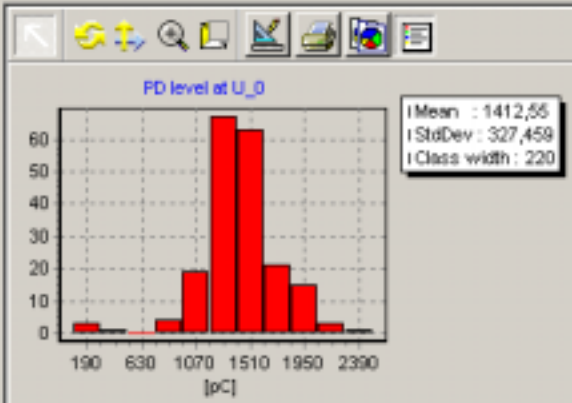
Worksheet OWTS

Measurements

- ☒ L1 10-3-1998
- ☒ L2 10-3-1998
- ☒ L3 10-3-1998
- ☒ L1 31-10-1998
- ☒ L2 31-10-1998
- ☒ L3 31-10-1998

Quantities

- ☒ PD level at U₀
- ☐ PD level at 2*U₀



Time Analysis

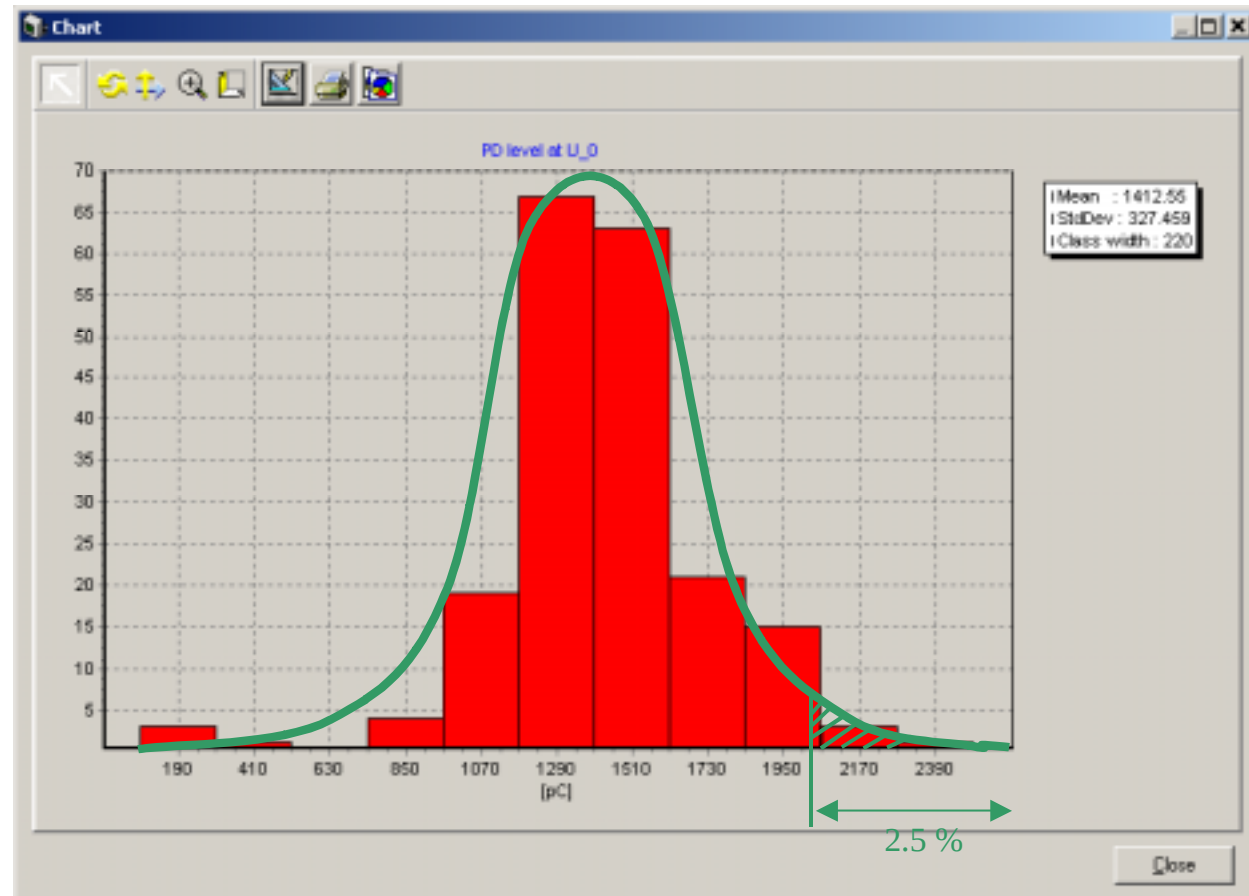
Trending two diagnostics quantities PDIV and PD level; Green area means that the degradation process is not critical for the insulation; red area indicates increased risk of failure.



Type Analysis

Example of knowledge rule generation by using databases; all detected PD levels from one type of component are reflected with the distribution.

PD level at U₀ for joint type A

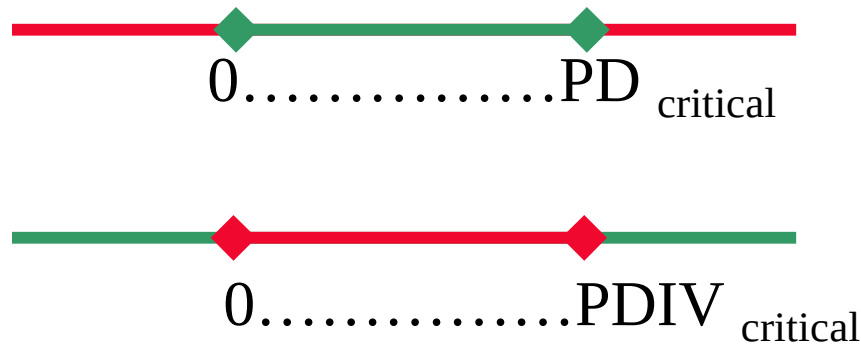


$$u = (x - \mu) / \sigma$$

$u = 1,96$ for 95% confidence interval

Norms

1D numeric quantity,
interval



1D multiple choice quantity,
subset of MC list



- For identification of components
- norms can exist for each combination of
 - measurement type,
 - component type
 - 1D quantity,

Filter



Filters



Component



Type



Group



Help



Exit

Filters

My selection

New Filter

Cables with high PDlevels

10 KV XLPE with possible overvoltage risk

Add

Update

Delete

Import filter

Export filter

Activate

Import data

Export results

Update Filter

Filter info

Filter name: Cables with high PDlevels

Measurement type: OWTS

Begin date: ☐ 29-6-2001 15:01:57

End date: ☐ 29-6-2001 15:01:57

Filter tree

- Cables with high PDlevels
 - Rule 1
 - CableSection : Type = GPLK
 - PD level at U_0 (CableSection) > 8000
 - Rule 2
 - CableSection : Type = XLPE
 - PD level at U_0 (CableSection) > 100

Value condition

PD level at U_0 (CableSection)

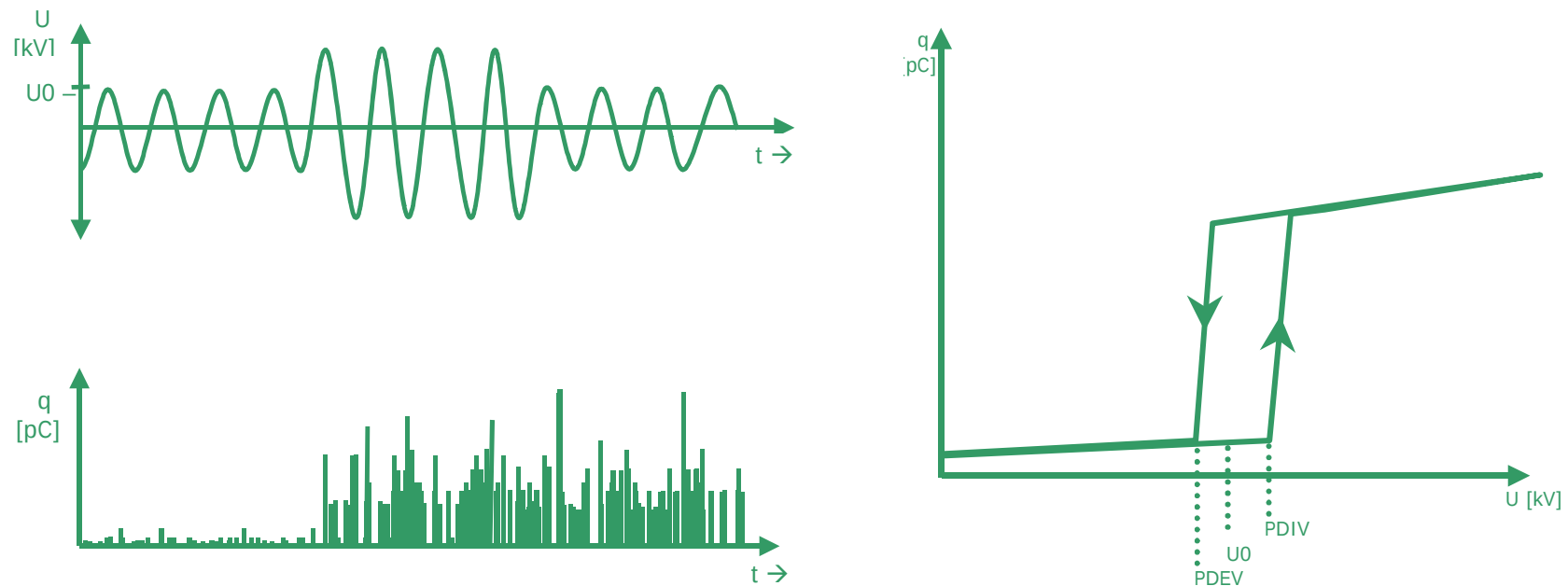
> 100 <<No quantity>>

Delete Condition

OK Cancel

Population Selection (1)

Temporary Overvoltages



Population Selection

Filter to select all 10kV XLPE cables with possible overvoltage risk

Update Filter

Filter info

Filter name: 10 kV XLPE with possible overvoltage risk

Measurement type: DWTs

Begin date: 2-7-2001 22:10:49

End date: 2-7-2001 22:10:49

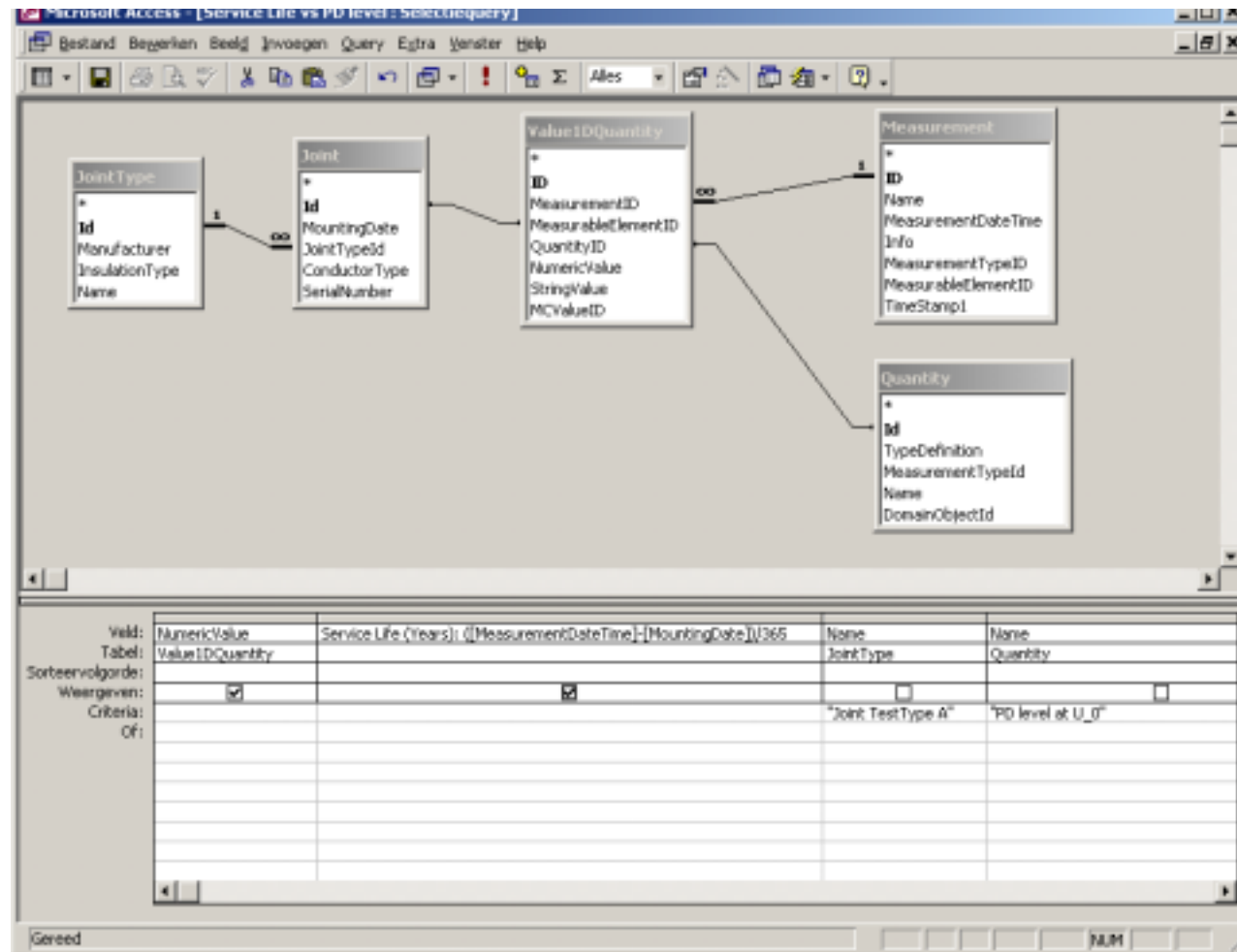
Filter tree

- 10 kV XLPE with possible overvoltage risk
 - Rule 1
 - CableSection : Type = XLPE
 - CableSection : VoltageClass = 10
 - PDIV (CableSection) > 10
 - PDEV (CableSection) < 10

OK Cancel

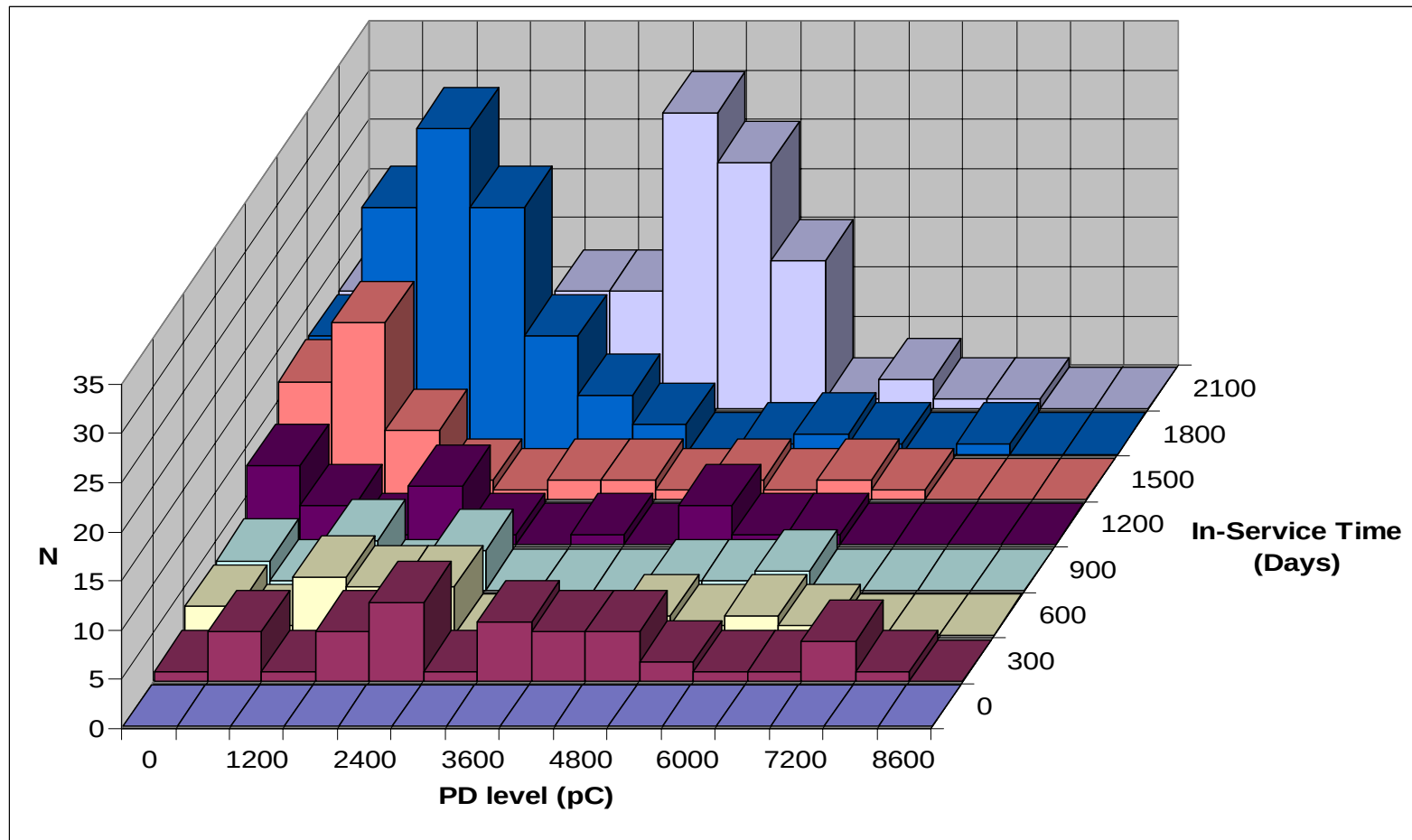
SQL / additional analysis

MS Access query to result in a dataset for a diagnostic parameter PD level versus service life.



SQL / additional analysis

In-Service Time = Measurement Date – Mounting Date



Data-mining and Databases Support for CBM of Distribution Power Cables

CONTENT

1. General aspects
2. Database structure
3. Data integrity
4. Use Cases

5. Conclusions

Conclusions

- Database support is an important element in obtaining relevant information for condition assessment of insulating systems, e.g. power cables.
- By using advanced non-destructive diagnostic techniques and storage of the measured quantities in a database, analysis can be performed to extract additional information not shown by the single measurements.
- Based on this information, decisions can be made about levels for updating or maintenance. When these levels are applied on the database as *norm levels*, components are easily selected for CBM actions.