Tutorial on:

Reliability of High Voltage Equipment

- Survey structure and organization
  Magne Runde (10 min)
- Circuit-breaker results
  Dirk Makareinis (20 min)
- Disconnector and earthing switch results
  Carsten Protze (20 min)
- Instrument transformer results
  Francis Waite (20 min)
- GIS results
  Dagmar Kopejtkova (20 min)
- Use of reliability data
  John Skog (15 min)

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Survey structure and organization

Magne Runde

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WG A3.06 tasks

- Create questionnaires
- Establishing computer tools for information handling
- Persuade utility representatives to participate
- Collect, quality check and store incoming data
- Prepare, analyse and publish the results

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Failure frequency calculation

$$\text{Failure freq.} = \frac{\#\text{ of failures}}{\#\text{ of components } x \text{ survey duration}} \quad [\text{year}^{-1}]$$

Example:

Two failures over a four-year period in a population of 25 circuit breakers

⇓

Failure frequency: 2.0 failures / 100 CB-years

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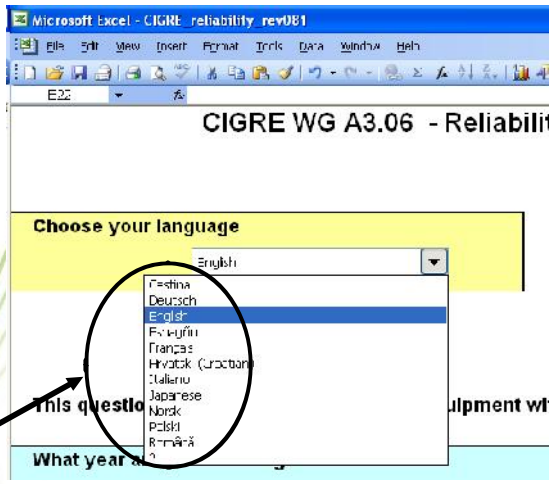
Excel tool for data collection

- Nine questionnaires organized in *Excel* workbook
- Distributed by e-mail
- Extensive “Help” function
- Answers extracted into a file that was returned
- 11 languages built in



Select language

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Population card

Push button and get help

card & Save

Single Pressure SF6 Circuit Breaker (CB)

height or zoom.

f e	Operating Mechanism ?	Type of Enclosure	Location ? ?	Number of CBs manufactured in Period: before 1979	1979-1983	1984-1988	1989-1993	1994-1998	1999-2003	2004-2007
line	1 : Hydraulic	1 : GIS - 1 phase	1 : Indoor							
er	2 : Pneumatic	2 : GIS - 3 phase	2 : Outdoor							
	3 : Spring	3 : Live tank	3 : GIS: Indoor-Normal							
ctor	4 : Other	4 : Dead tank	4 : GIS: Indoor-Special							
			5 : GIS: Outdoor-Normal							
er			6 : GIS: Outdoor-Special							
			7 : hybrid GIS: Indoor-Normal							
			8 : hybrid GIS: Indoor-Special							
			9 : hybrid GIS: Outdoor-Normal							
	2	1	2	12	2			6		
	4	4	1			2			12	

Numbers filled in by the utility

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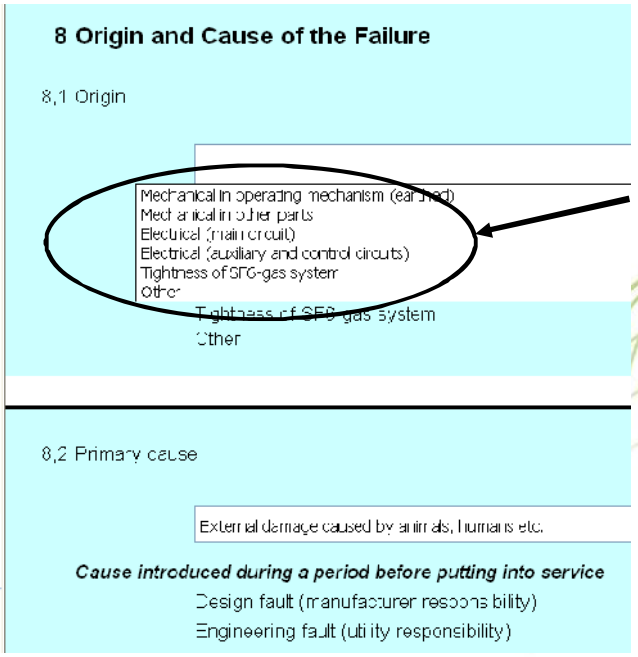
Failure card



The utility selected answers among alternatives listed in drop down menus

Failure types

IEC 60694 definitions were adopted:

Major failure (MaF): "*failure of a switchgear and control gear which causes the cessation of one or more of its fundamental functions. A major failure will result in an immediate change in the system operating conditions, e.g. the backup protective equipment will be required to remove the fault, or will result in mandatory removal from service within 30 minutes for unscheduled maintenance*".

Minor failure (MiF): "*failure of an equipment other than a major failure or any failure, even incomplete, of a constructional element or a sub-assembly which does not cause a major failure*"

Difficulties and shortcomings

- Biased survey participation
- Underreporting of failures
- Not all data solicited available to utility
- Incompletely filled forms / cards / questionnaires
- Questions misunderstood

But:

The quick & easy way of obtaining reliability data does not exist

Failure statistics - with known shortcomings - are of great value

Technical Brochures under way

"Final Report of the 2004 – 2007 International Enquiry on Reliability of High Voltage Equipment"

"Part 1: Summary and General Matters"

"Part 2: SF_6 Circuit Breakers"

"Part 3: Disconnectors and Earthing Switches"

"Part 4: Instrument Transformers"

"Part 5: Gas Insulated Switchgear"

"Part 6: GIS Practices"