

C57.104

Spring 2013

Munich

March 19, 2013

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Factors influencing Percentile

- Transformer are not all equal
- They differ in voltage, size, loading factor, type of construction, environment, age, material, supplier...
- What influence have these difference on their gassing tendency?
- Does size matter? Age? Load? ...?
- How much influence, if any?

Factors influencing 90 Percentile

- With the data set in hand, it is possible to answer some of these questions.
- Data set is not complete. Some info are missing (Load among other)
- We could study some influence on Percentile values:
 - Age
 - MVA
 - KV
 - % O₂

Factors influencing Percentile

- To evaluate the influence of each available parameters, the data was subdivided in smaller groups according to each parameter values
- One parameter at the time was studied (MVA, KV..)
- All available data sources were combined
- Percentile is computed for each subgroup

Factors influencing Percentile

- The subdivisions are as follow:
 - Age: 8 Groups
<10, 10-20, 20-30 ... >70 years
 - MVA: 8 Groups
<1, 1-5, 5-10, 10-20, 20-50, 50-100, 100-500, >500 MVA
 - KV: 4 Groups
<34.5, 34.5–69, 69-230, >230 KV
 - % O₂: 6 Groups
<2, 2-5, 5-10, 10-15, 15-20, >20 %O₂

Factors influencing Percentile

- For each gas in each group, the 90 and 95 Percentile are computed
- The range of variation between same percentile value for a given parameter is computed (Max/Min)
- A value of 1 indicate no influence from the studied parameter (Min = Max)
- Results are as follow for the 90 and 95 Percentile:

Comparison 90 Percentile Spread

| %O2 | | |
|-----------------|------|------------|
| Min | Max | Max/Min |
| 48 | 120 | 2.5 |
| 23 | 120 | 5.2 |
| 0 | 3 | |
| 53 | 73 | 1.4 |
| 16 | 168 | 10.5 |
| 474 | 855 | 1.8 |
| 5016 | 9100 | 1.8 |
| 672 | 1162 | 1.7 |
| Average: | | 3.6 |

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| H2 |
| CH4 |
| C2H2 |
| C2H4 |
| C2H6 |
| CO |
| CO2 |
| TDCG |

| Years | | |
|-----------------|------|------------|
| Min | Max | Max/Min |
| 62 | 235 | 3.8 |
| 43 | 113 | 2.6 |
| 0 | 3 | |
| 16 | 73 | 4.6 |
| 33 | 133 | 4.0 |
| 586 | 1034 | 1.8 |
| 3221 | 9673 | 3.0 |
| 747 | 1391 | 1.9 |
| Average: | | 3.1 |

| MVA | | |
|-----------------|------|------------|
| Min | Max | Max/Min |
| 62 | 146 | 2.4 |
| 65 | 193 | 3.0 |
| 0 | 3 | |
| 40 | 135 | 3.4 |
| 71 | 208 | 2.9 |
| 502 | 833 | 1.7 |
| 4594 | 9010 | 2.0 |
| 930 | 1158 | 1.2 |
| Average: | | 2.4 |

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| H2 |
| CH4 |
| C2H2 |
| C2H4 |
| C2H6 |
| CO |
| CO2 |
| TDCG |

| KV | | |
|-----------------|------|------------|
| Min | Max | Max/Min |
| 72 | 154 | 2.1 |
| 67 | 136 | 2.0 |
| 0 | 3 | |
| 42 | 75 | 1.8 |
| 66 | 143 | 2.2 |
| 574 | 809 | 1.4 |
| 4503 | 9049 | 2.0 |
| 927 | 1170 | 1.3 |
| Average: | | 1.8 |

Comparison 95 Percentile Spread

| % O2 | | |
|-----------------|-------|------------|
| Min | Max | Max/Min |
| 105 | 263 | 2.5 |
| 69 | 204 | 3.0 |
| 2 | 11 | 5.5 |
| 122 | 159 | 1.3 |
| 52 | 293 | 5.6 |
| 603 | 1061 | 1.8 |
| 6850 | 12224 | 1.8 |
| 966 | 1599 | 1.7 |
| Average: | | 2.9 |

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| H2 |
| CH4 |
| C2H2 |
| C2H4 |
| C2H6 |
| CO |
| CO2 |
| TDCG |

| Years | | |
|-----------------|------|------------|
| Min | Max | Max/Min |
| 123 | 351 | 2.9 |
| 87 | 193 | 2.2 |
| 2 | 6 | 3.0 |
| 38 | 126 | 3.3 |
| 71 | 225 | 3.2 |
| 748 | 947 | 1.3 |
| 4574 | 9128 | 2.0 |
| 981 | 1415 | 1.4 |
| Average: | | 2.4 |

| MVA | | |
|-----------------|-------|------------|
| Min | Max | Max/Min |
| 100 | 548 | 5.5 |
| 126 | 292 | 2.3 |
| 3 | 10 | 3.3 |
| 80 | 367 | 4.6 |
| 158 | 319 | 2.0 |
| 738 | 1050 | 1.4 |
| 6747 | 12235 | 1.8 |
| 1221 | 2024 | 1.7 |
| Average: | | 2.8 |

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| H2 |
| CH4 |
| C2H2 |
| C2H4 |
| C2H6 |
| CO |
| CO2 |
| TDCG |

| KV | | |
|-----------------|-------|------------|
| Min | Max | Max/Min |
| 156 | 558 | 3.6 |
| 131 | 263 | 2.0 |
| 3 | 9 | 3.0 |
| 80 | 181 | 2.3 |
| 150 | 229 | 1.5 |
| 764 | 1002 | 1.3 |
| 6635 | 12110 | 1.8 |
| 1251 | 1973 | 1.6 |
| Average: | | 2.1 |

Observation

- When Data is divided according to characteristic such as %O₂, Age, Power and Voltage, large variations between sub populations are observed
- These variations range from a 1.2 factor (20% variation) to a factor over 10 (1000% variation)

Observation for 90 Percentile

- The largest average variations (3.6) are observed in function of the factor $O_2/(O_2+N_2)$ (% O_2)
- The second largest sets of variation are from Age and Power rating (3.1 & 2.4)
- The smallest variations are observed for Voltage Class (1.8)
- This need to be taken into account to improve interpretation

Observation for 95 Percentile

- As for the 90 Percentile, the largest average variations (2.9) are observed in function of the factor $O_2/(O_2+N_2)$ (% O_2)
- The second largest sets of variation are also from Age and Power rating (2.4 & 2.8)
- The smallest variations are observed for Voltage Class (2.1)
- There is less variation of spread between groups than for the 90 Percentile

Observation

- Use of statistical value, such as 90 or 95 Percentile, will need to be qualified by a more precise description of the population used as reference
- Multi-factors selection will likely be required
- Example: Division by %O₂ and Age:

Comparison 90 Percentile Spread for %O₂ and Age

| < 5% O2 Age | | |
|-----------------|------|------------|
| Min | Max | Max/Min |
| 68 | 250 | 3.7 |
| 24 | 130 | 5.4 |
| 0 | 1 | |
| 7 | 63 | 8.6 |
| 18 | 168 | 9.3 |
| 267 | 796 | 3.0 |
| 1468 | 7529 | 5.1 |
| 460 | 1217 | 2.6 |
| Average: | | 5.4 |

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| H2 |
| CH4 |
| C2H2 |
| C2H4 |
| C2H6 |
| CO |
| CO2 |
| TDCG |

| 5% - 15% O2 Age | | |
|-----------------|------|------------|
| Min | Max | Max/Min |
| 51 | 256 | 5.0 |
| 24 | 118 | 4.9 |
| 1 | 2 | 2.0 |
| 6 | 76 | 12.7 |
| 11 | 120 | 11.0 |
| 279 | 945 | 3.4 |
| 1162 | 7878 | 6.8 |
| 426 | 1169 | 2.7 |
| Average: | | 6.1 |

| > 15% O2 Age | | |
|-----------------|------|------------|
| Min | Max | Max/Min |
| 38 | 112 | 2.9 |
| 15 | 75 | 5.0 |
| 2 | 4 | 2.0 |
| 11 | 120 | 10.9 |
| 5 | 23 | 4.6 |
| 260 | 739 | 2.8 |
| 1160 | 6346 | 5.5 |
| 414 | 981 | 2.4 |
| Average: | | 4.5 |

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| H2 |
| CH4 |
| C2H2 |
| C2H4 |
| C2H6 |
| CO |
| CO2 |
| TDCG |

| All % O2 Age | | |
|-----------------|------|-------------|
| Min | Max | Max/Min |
| 38 | 256 | 6.7 |
| 15 | 130 | 8.7 |
| 0 | 4 | |
| 6 | 120 | 20.0 |
| 5 | 168 | 33.6 |
| 260 | 945 | 3.6 |
| 1160 | 7878 | 6.8 |
| 414 | 1217 | 2.9 |
| Average: | | 11.8 |

Observation

- For a given equipment, a multi criteria table is closer to the real situation than actual Table 1
- But more detailed table have inconvenient:
 - Difficult to read
 - False sense of precision
 - Will need to be further subdivided
- Simplification is required
 - Grouping to reduce the number of categories
 - Rounding values
 - ...

Other parameters

- The situation is similar with the other parameters:
 - MVA and %O₂
 - KV and %O₂

Comparison 90 Percentile Spread for %O₂ and MVA

| < 5% O2 MVA | | |
|-----------------------|-------|------------|
| Min | Max | Max/Min |
| 67 | 135 | 2.0 |
| 85 | 232 | 2.7 |
| 0 | 1 | |
| 32 | 253 | 7.9 |
| 107 | 252 | 2.4 |
| 553 | 979 | 1.8 |
| 4697 | 12228 | 2.6 |
| 955 | 1344 | 1.4 |
| Average: | | 3.0 |

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|------|
| H2 |
| CH4 |
| C2H2 |
| C2H4 |
| C2H6 |
| CO |
| CO2 |
| TDCG |

| 5 - 15% O2 MVA | | |
|-----------------------|-------|------------|
| Min | Max | Max/Min |
| 52 | 137 | 2.6 |
| 67 | 153 | 2.3 |
| 0 | 3 | |
| 43 | 89 | 2.1 |
| 63 | 138 | 2.2 |
| 591 | 950 | 1.6 |
| 5065 | 10145 | 2.0 |
| 897 | 1317 | 1.5 |
| Average: | | 2.0 |

| > 15% O2 MVA | | |
|------------------------|------|------------|
| Min | Max | Max/Min |
| 47 | 103 | 2.2 |
| 17 | 94 | 5.5 |
| 2 | 6 | 3.0 |
| 46 | 77 | 1.7 |
| 13 | 68 | 5.2 |
| 371 | 550 | 1.5 |
| 3274 | 7378 | 2.3 |
| 616 | 847 | 1.4 |
| Average: | | 2.8 |

| |
|------|
| H2 |
| CH4 |
| C2H2 |
| C2H4 |
| C2H6 |
| CO |
| CO2 |
| TDCG |

| All % O2 MVA | | |
|---------------------|-------|------------|
| Min | Max | Max/Min |
| 47 | 137 | 2.9 |
| 17 | 232 | 13.6 |
| 0 | 6 | |
| 32 | 253 | 7.9 |
| 13 | 252 | 19.4 |
| 371 | 979 | 2.6 |
| 3274 | 12228 | 3.7 |
| 616 | 1344 | 2.2 |
| Average: | | 7.5 |

Comparison 90 Percentile Spread for %O₂ and KV

| < 5% O2 KV | | |
|-----------------|-------|------------|
| Min | Max | Max/Min |
| 84 | 154 | 1.8 |
| 100 | 149 | 1.5 |
| 0 | 1 | |
| 38 | 65 | 1.7 |
| 130 | 187 | 1.4 |
| 594 | 945 | 1.6 |
| 5151 | 11524 | 2.2 |
| 1004 | 1258 | 1.3 |
| Average: | | 1.6 |

| |
|------|
| H2 |
| CH4 |
| C2H2 |
| C2H4 |
| C2H6 |
| CO |
| CO2 |
| TDCG |

| 5 - 15% O2 KV | | |
|-----------------|------|------------|
| Min | Max | Max/Min |
| 70 | 190 | 2.7 |
| 63 | 117 | 1.9 |
| 1 | 2 | |
| 51 | 79 | 1.5 |
| 51 | 111 | 2.2 |
| 733 | 913 | 1.2 |
| 5597 | 9577 | 1.7 |
| 995 | 1354 | 1.4 |
| Average: | | 1.8 |

| > 15% O2 KV | | |
|-----------------|------|------------|
| Min | Max | Max/Min |
| 45 | 139 | 3.1 |
| 17 | 68 | 4.0 |
| 2 | 7 | |
| 53 | 107 | 2.0 |
| 13 | 40 | 3.1 |
| 506 | 708 | 1.4 |
| 4793 | 6430 | 1.3 |
| 686 | 985 | 1.4 |
| Average: | | 2.3 |

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|------|
| H2 |
| CH4 |
| C2H2 |
| C2H4 |
| C2H6 |
| CO |
| CO2 |
| TDCG |

| All % O2 KV | | |
|-----------------|-------|------------|
| Min | Max | Max/Min |
| 45 | 190 | 4.2 |
| 17 | 149 | 8.8 |
| 0 | 7 | |
| 38 | 107 | 2.8 |
| 13 | 187 | 14.3 |
| 506 | 945 | 1.9 |
| 4793 | 11524 | 2.4 |
| 686 | 1354 | 2.0 |
| Average: | | 5.2 |

Upcoming

- Streamline and find way to simplify table
- Include data received in last year in study
 - Pending IEEE data handling policy
- Look at 3 parameters correlation:
 - Age and MVA and %O₂
 - Age and KV and %O₂
 - Age and KV and MVA
 - KV and MVA and %O₂

To be continued