
Partial Discharge Testing: A Progress Report

Trends of Percentiles

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What Are Partial Discharges?

- Small electrical sparks in air-filled cavities in or adjacent to HV electrical insulation
- Occur because breakdown strength of
 - air (**3 kV/mm**) < solid insulation (**~300 kV/mm**)
- PD creates small voltage pulses
 - PD monitoring measures these small pulses



Standardization

- **Sensors**
- 80pF capacitive couplers
- stator slot couplers
- RFCT

- **Test Set-up**
- High SNR
- Noise elimination

PDA-IV™

TGA™

Portable instruments only

- 27,000 installations

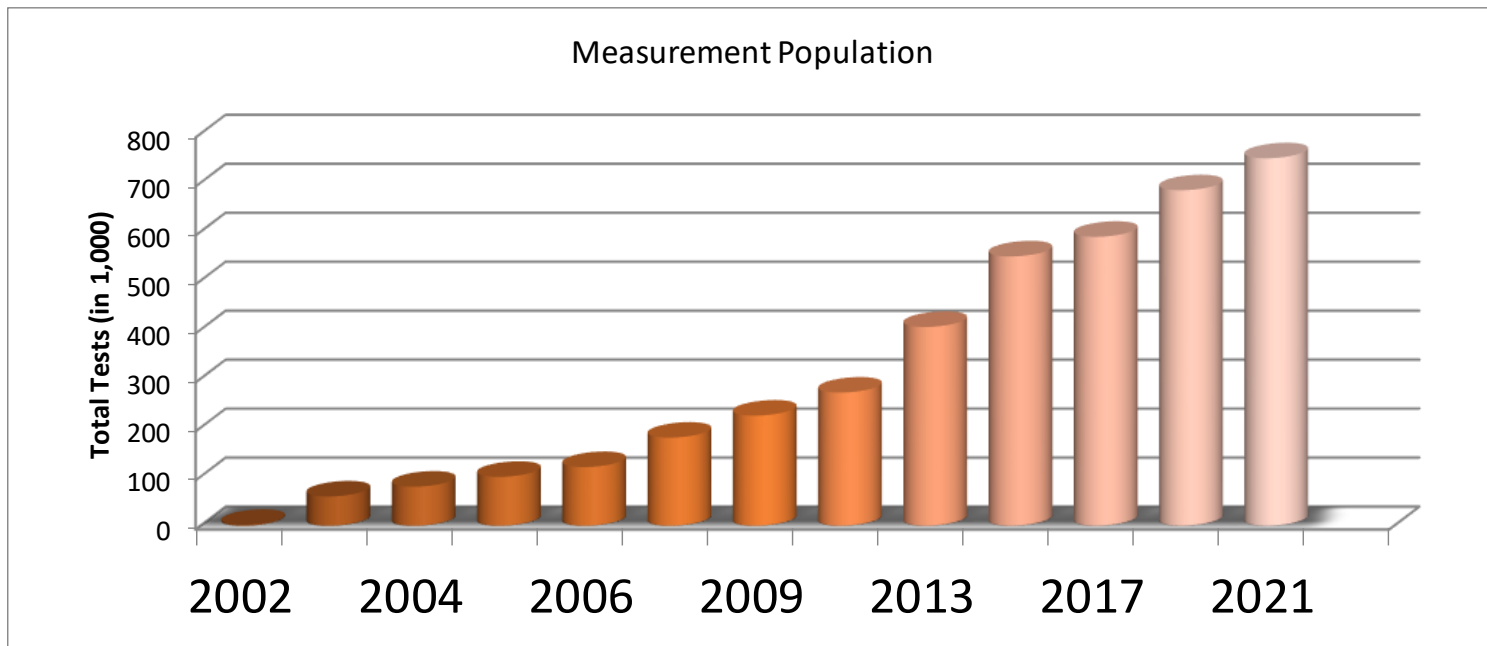
- **8,500 machines in database**

Data Analysis (> 750,000)

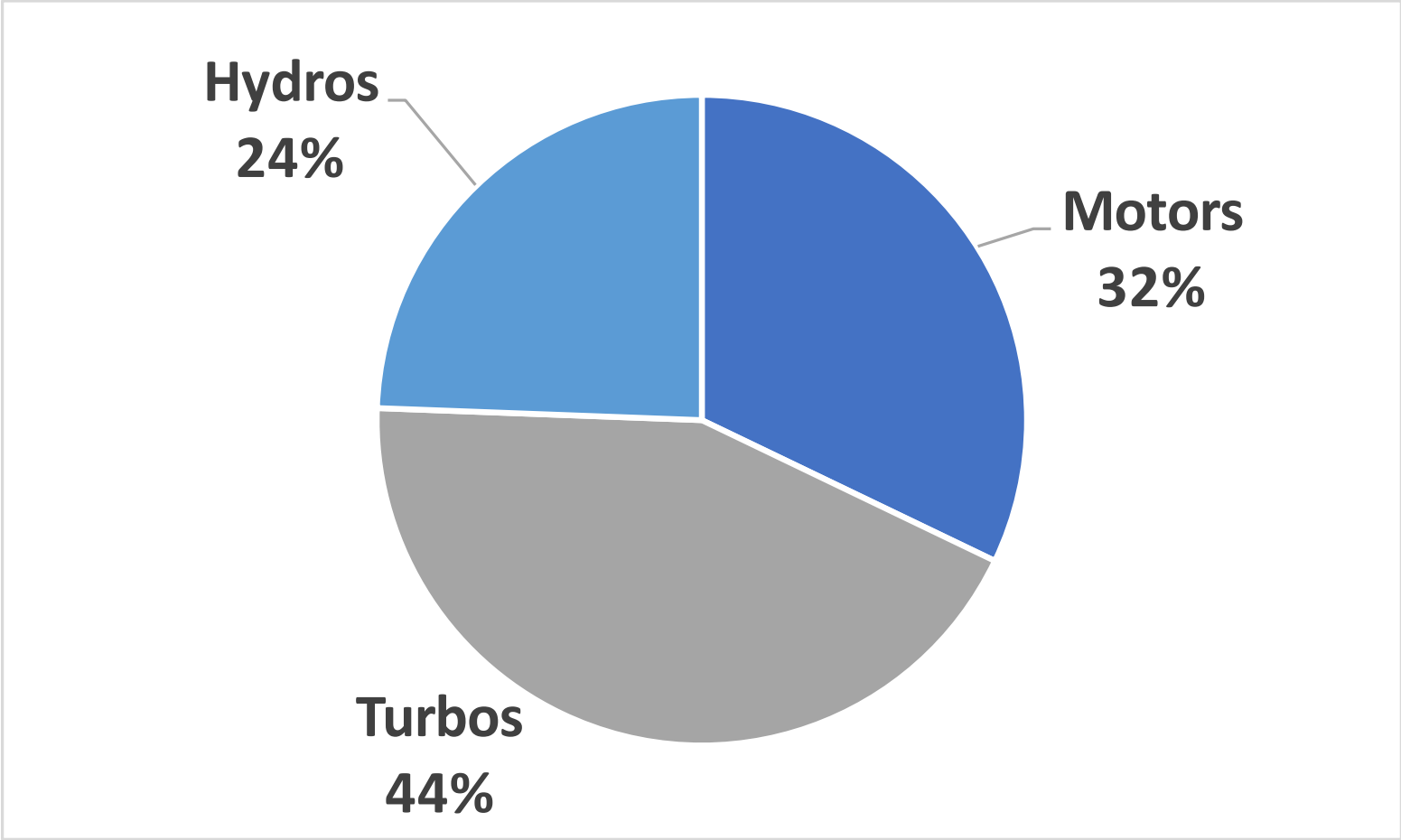
- **Full load hot tests online**
 - VHF and disturbance separation
- **Data separated by**
 - installation
 - insulation
 - voltage class
 - gas coolant pressures
 - manufacturer

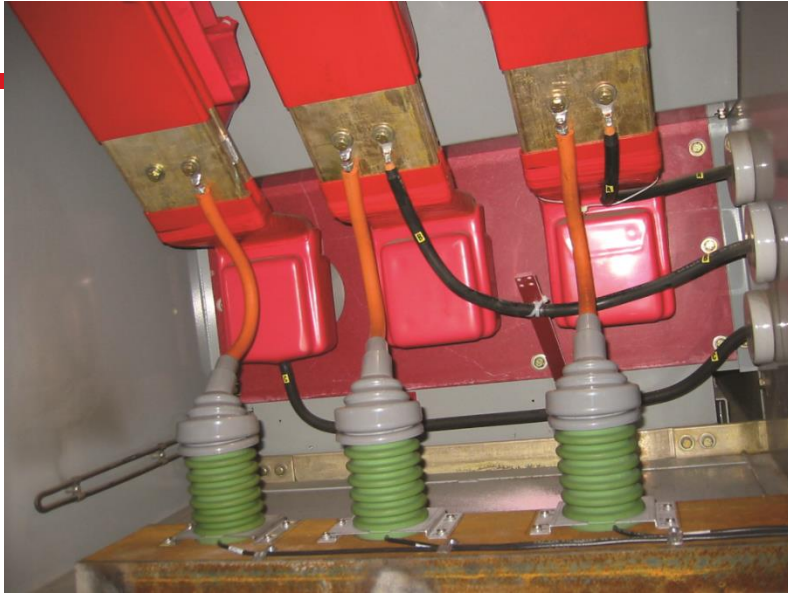
Statistical Database

- Population
 - 750,302 measurements for 2021 database
 - High temperature and high load measurements



Data collected through 2021





Turbos

80pF sensors



Motors

80pF sensors at the Terminals

Average over the 25 years

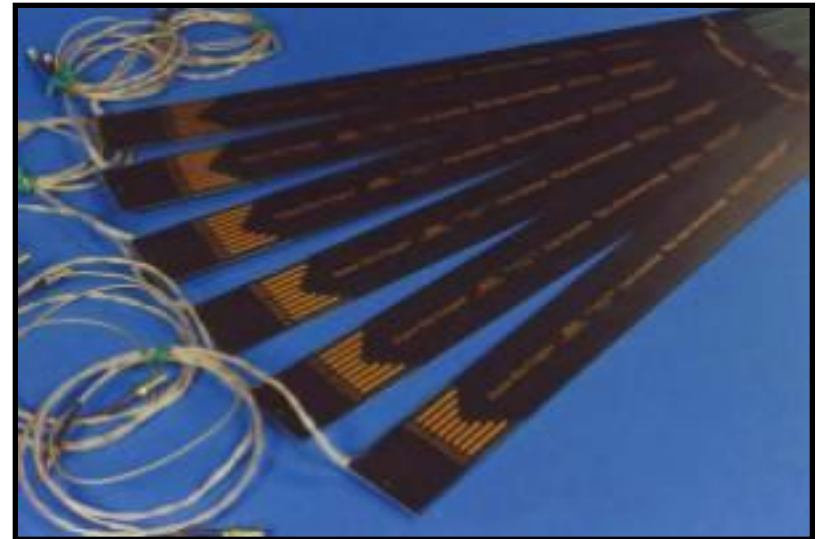
kV	$\geq 6 < 10$	$\geq 10 < 13$	$\geq 13 < 16$	$\geq 16 < 19$
25%	21	32	45	42
50%	55	78	111	85
75%	141	175	239	186
90%	308	368	488	346

PD > 90% indicates problems

Tables for other sensors

In Appendix

- Hydrogenerators
- Hydrogen-cooled Bus
- Air-cooled SSC
- Hydrogen-cooled SSC





Questions

- 1. Have the analysis results over the past 25 years been stable?**
 - **Stability would lead to confidence**

- 2. Are the results unstable?**
 - **Instability would lead to caution and the assets own trend would be more important**

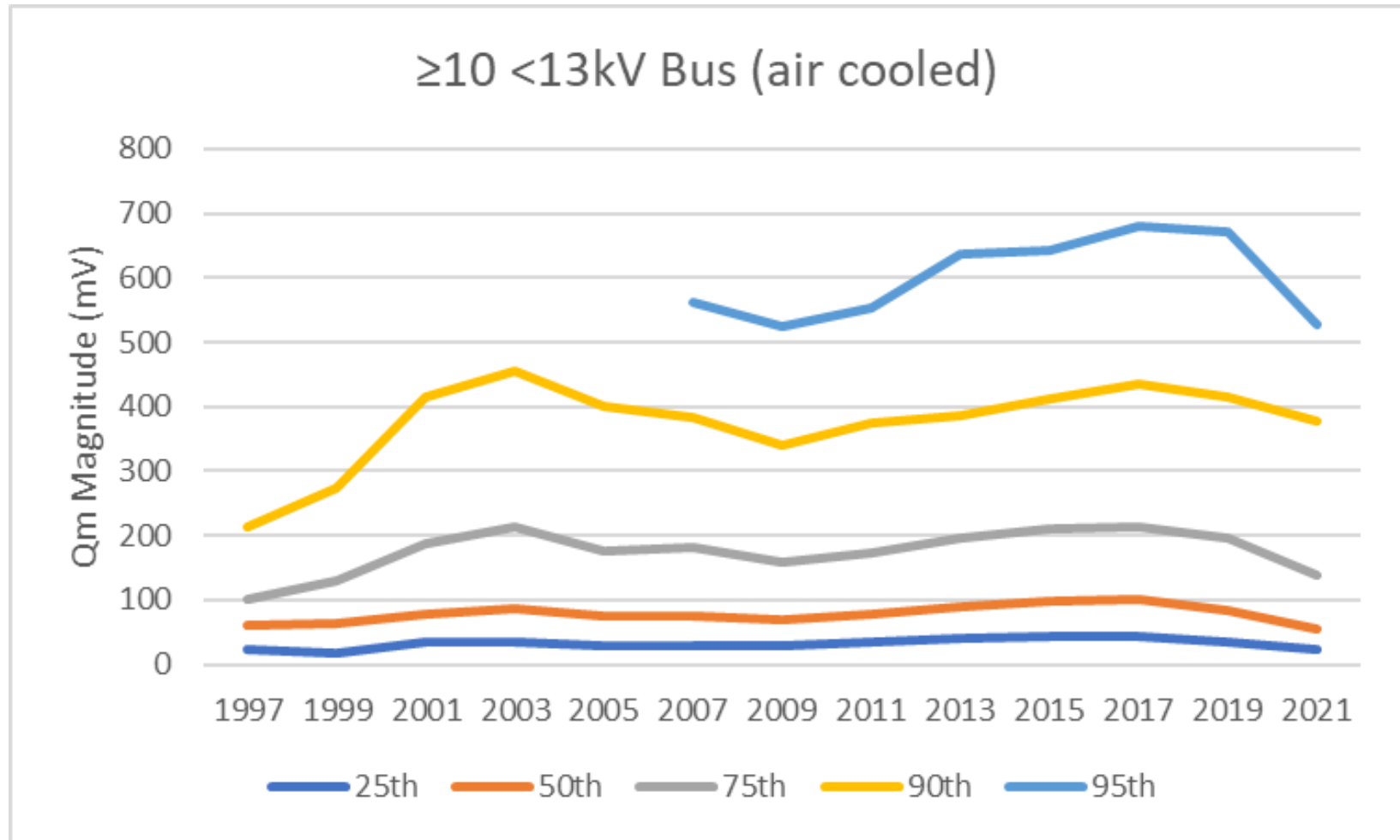


Questions

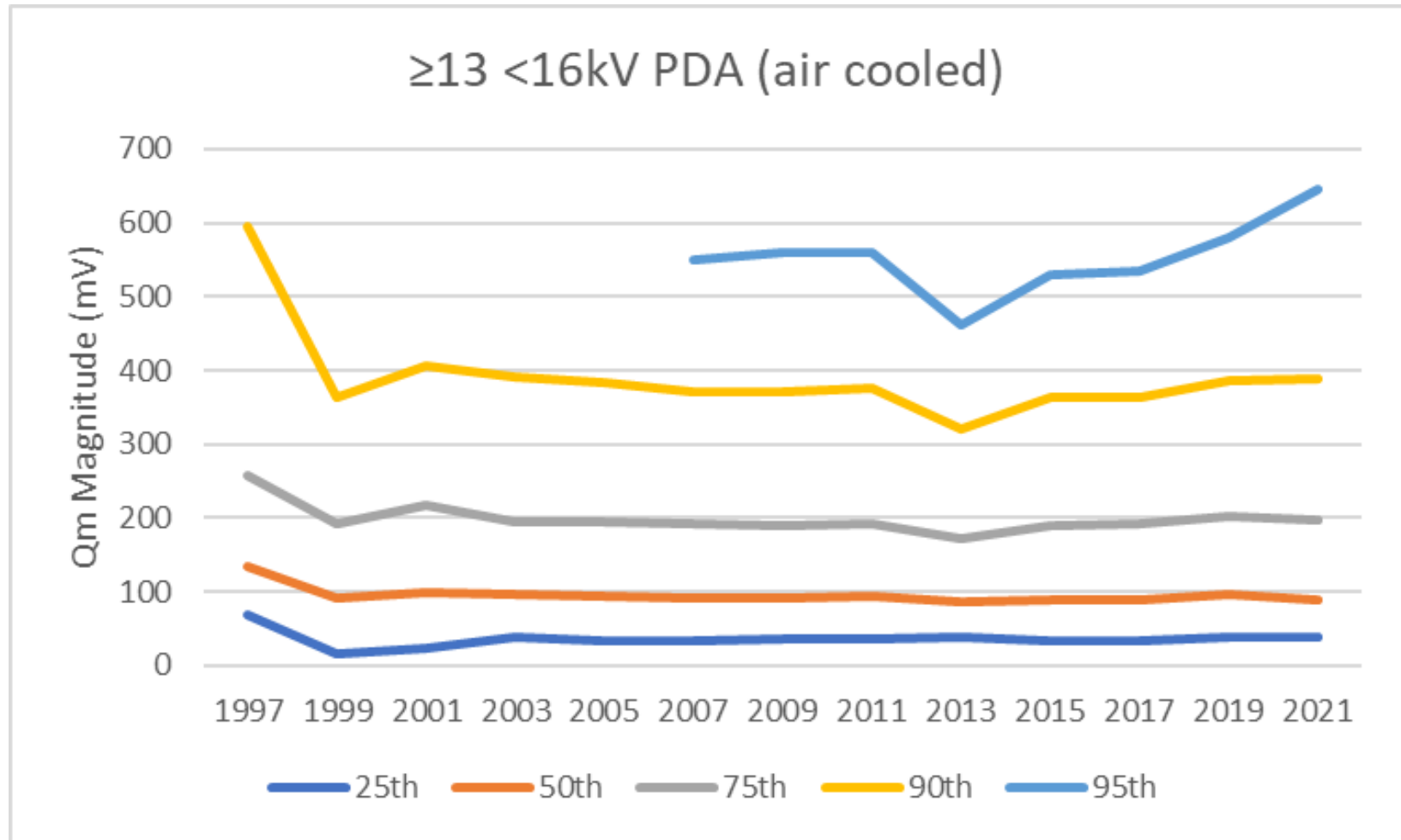
- 1. Have the analysis results over the past 25 years been stable?**
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Yes for 226 of the 235 categories, 96%

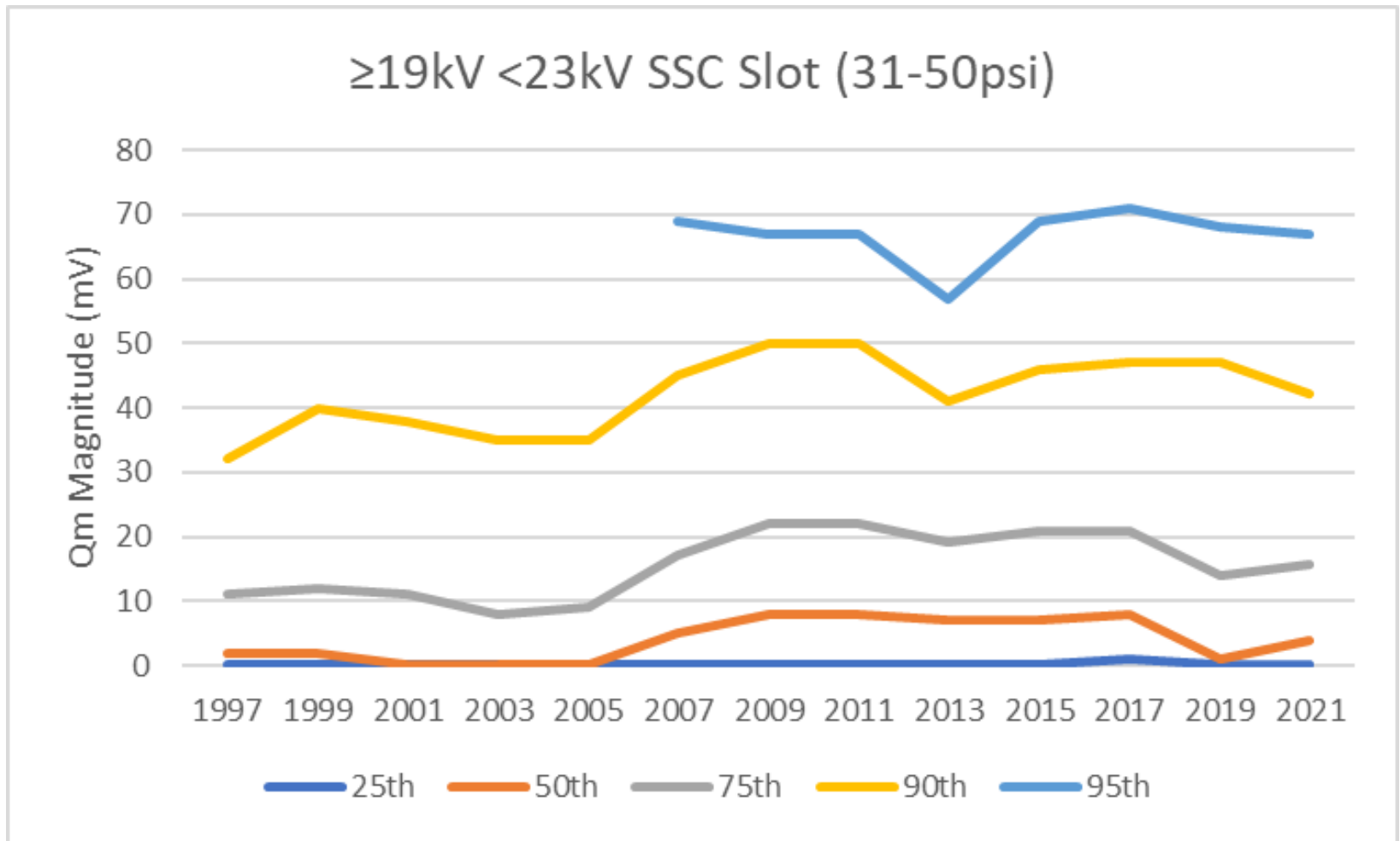
BUS, 10-12kV, air-cooled



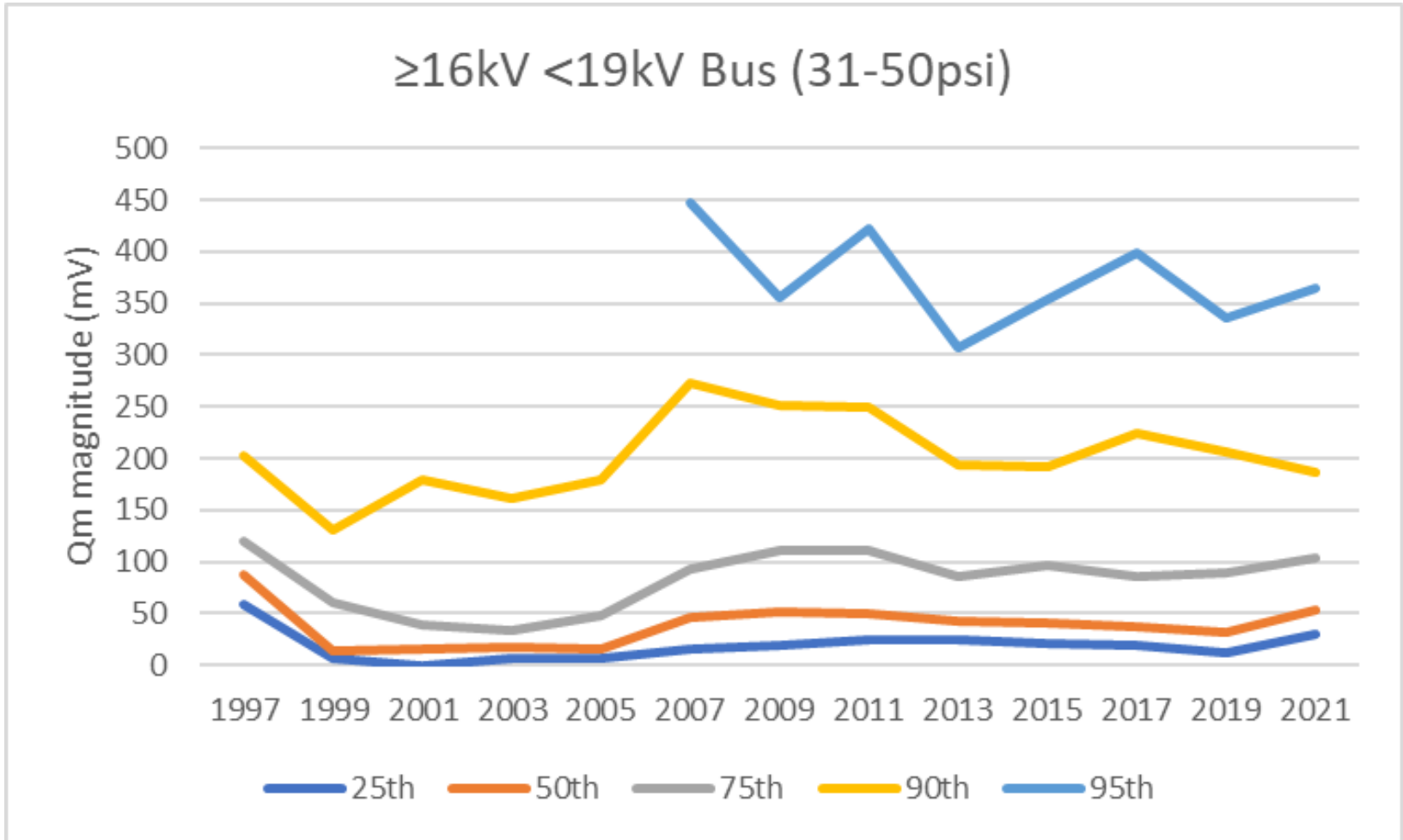
PDA, 13-16kV, air-cooled



SSC slot, 19-23kV, 31-50psi



BUS, 16-19kV, 31-50psi



Observations (speculations)

- For 96% of the categories, the data values have been relatively consistent over the 25 years
- So for these, the results can be used with confidence to determine negligible, low, typical, moderate, high and very high



Questions

1. Have the analysis results over the past 25 years been stable? Yes for 226 of the 235 categories, 96%
 - Stability would lead to confidence
2. **Are the results unstable?**
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Questions

1. Have the analysis results over the past 25 years been stable? Yes for 226 of the 235 categories, 96%

- Stability would lead to confidence

2. **Are the results unstable?**

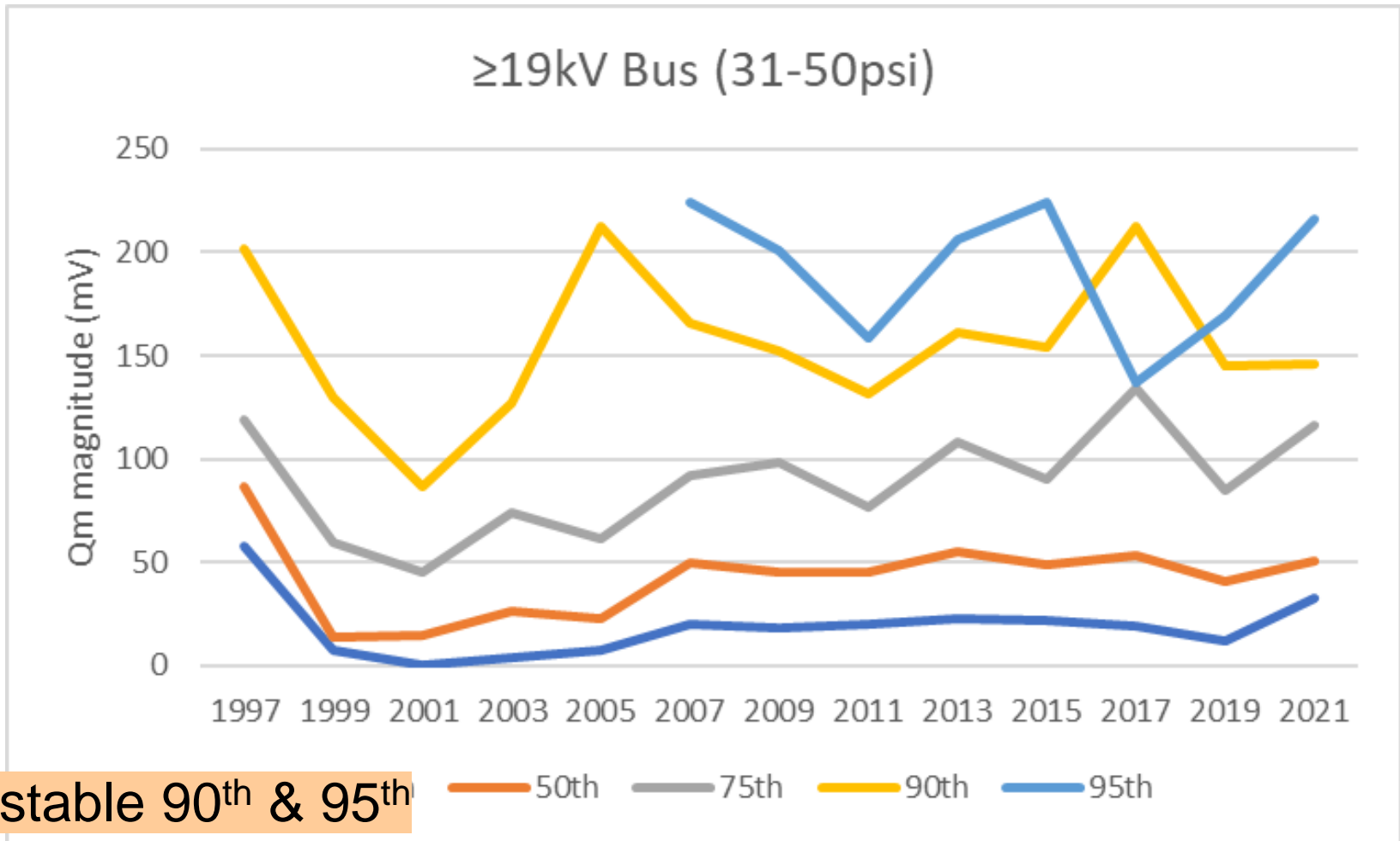
- **Instability would lead to caution and the assets own trend would be more important**

Yes for 9 of the 235 categories, 4%

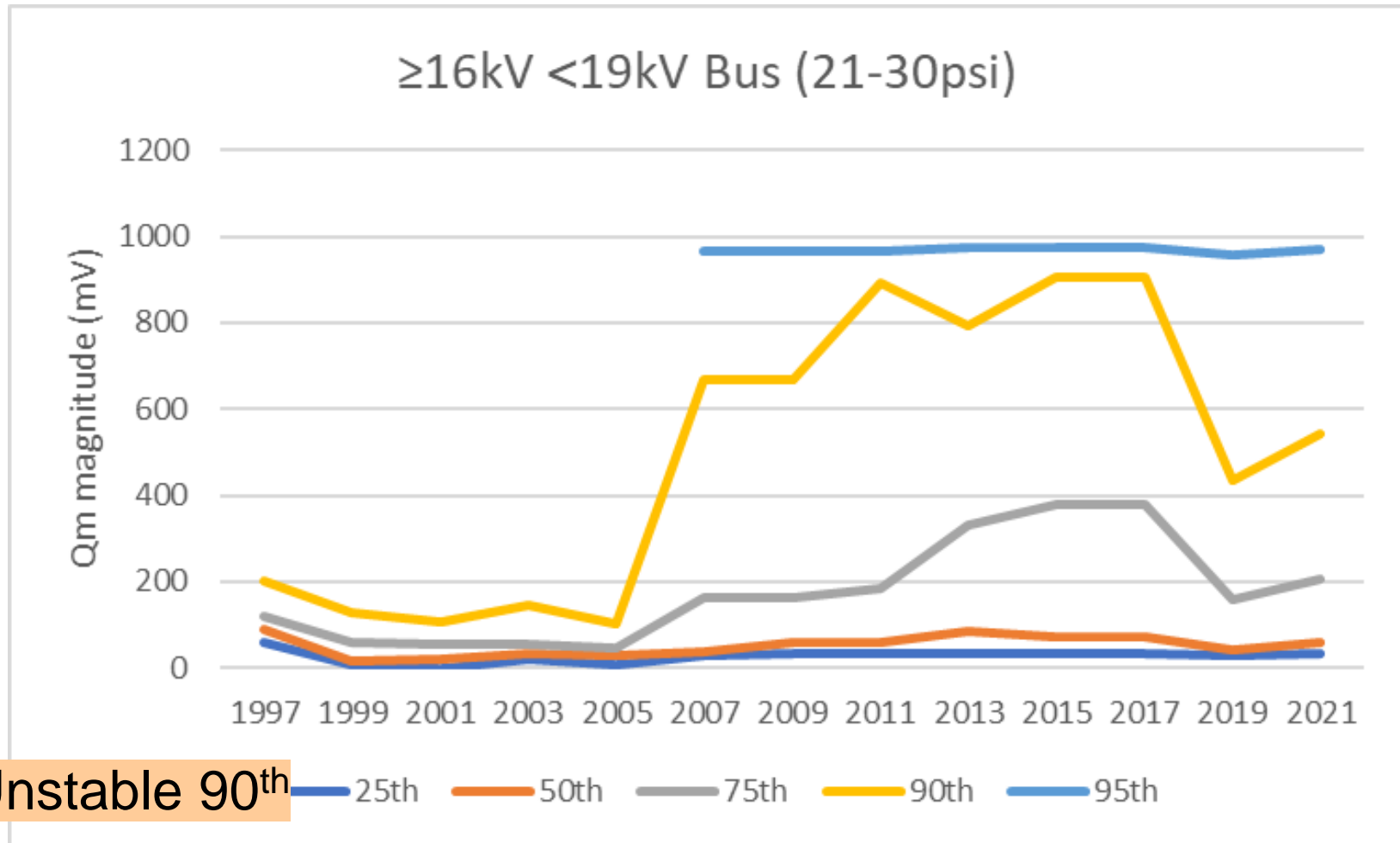
All 90th, 95th percentiles

5 for SSC Endwinding

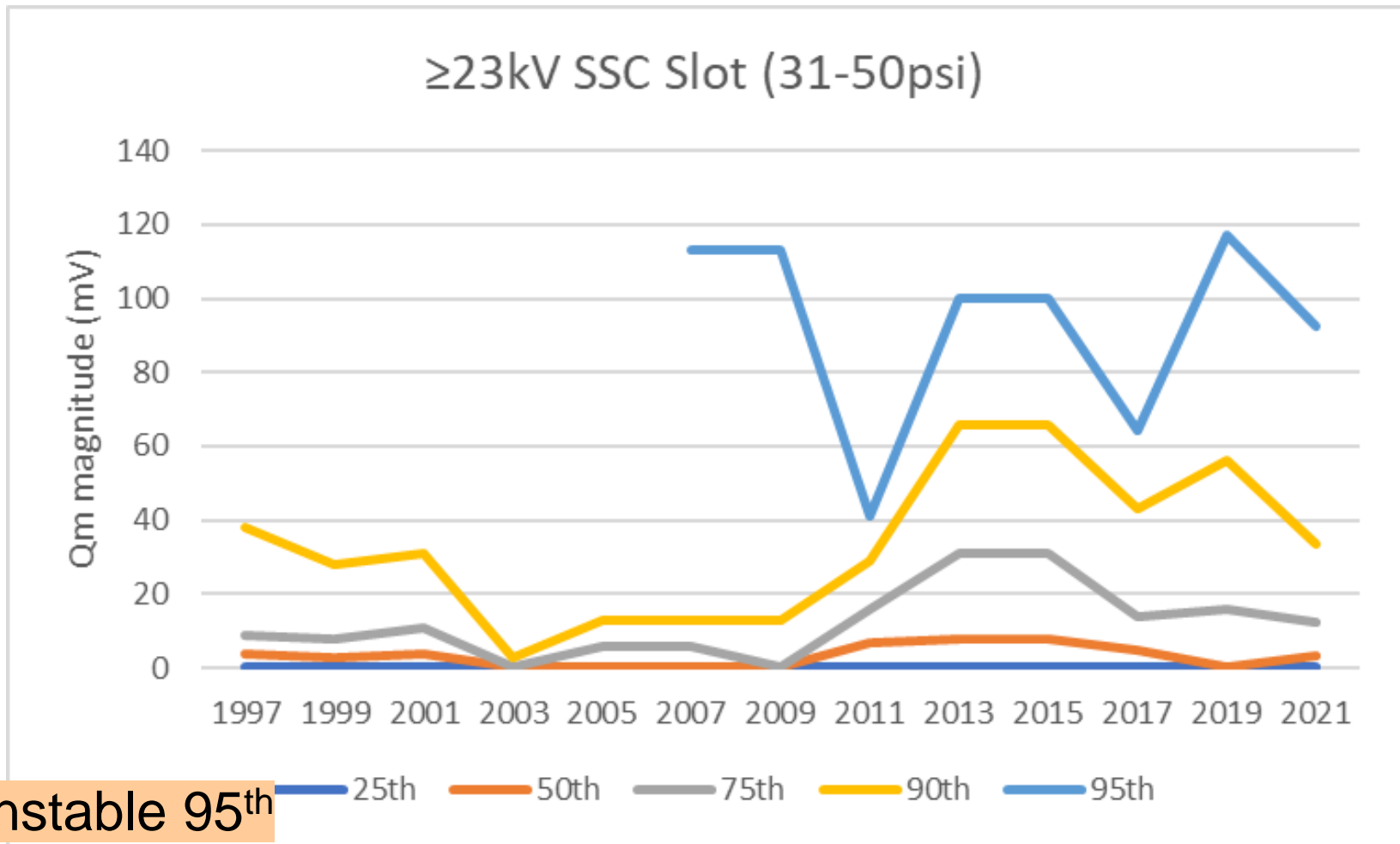
BUS, >19kV, 31-50psi



BUS, >16 <19kV, 21-30psi

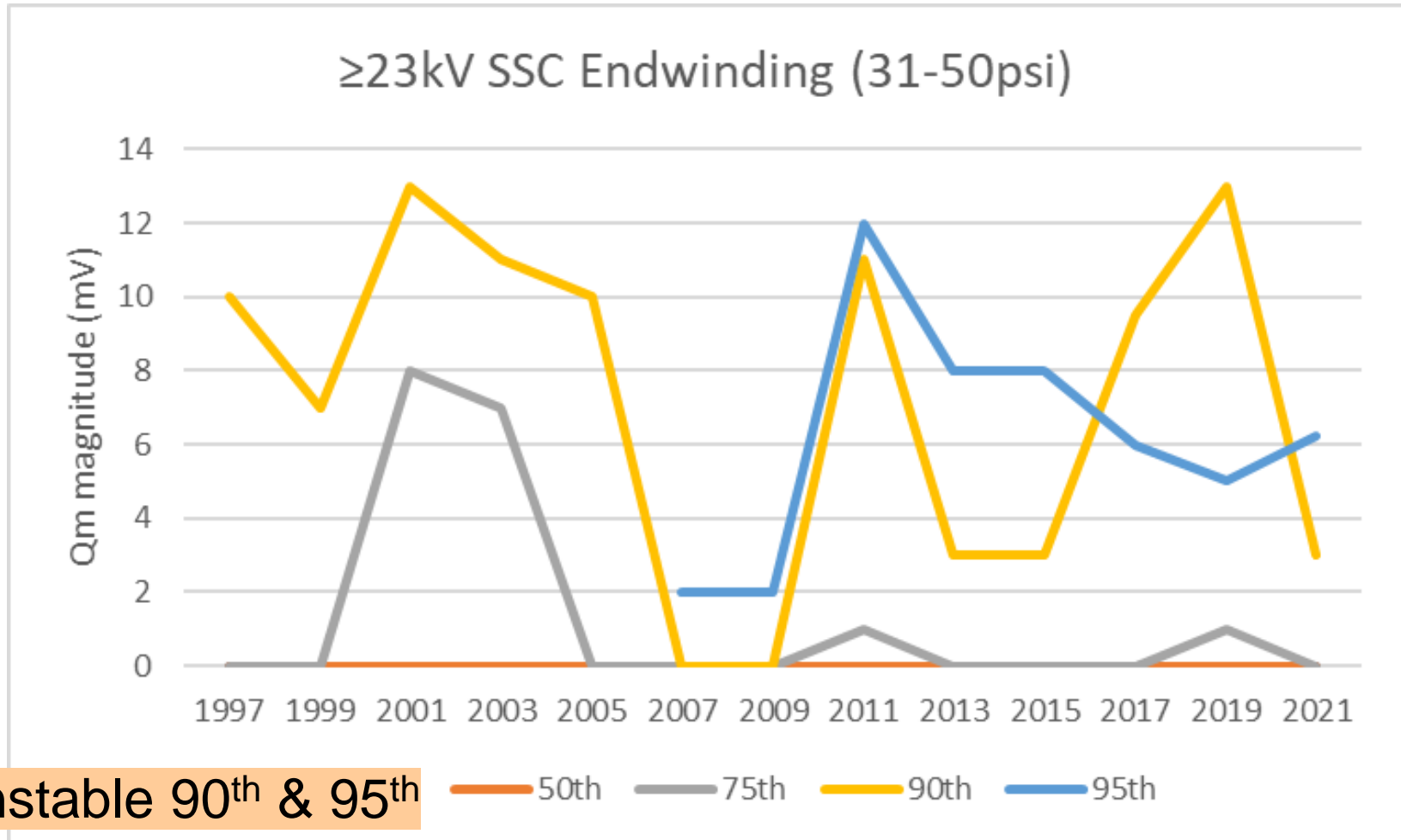


SSC Slot, >23kV, 31-50psi



Unstable 95th

SSC EW, >23kV, 31-50psi



Observations (speculations)

Possible reasons for the variability are:

- Low magnitude Q_m values where small changes greatly impact the trends**
- Initially a small sample size that steadily increased over the years**
- Small sample size throughout the years**
- Possible incorrect recording of the operating parameters during testing, especially the actual operating gas pressure**



Questions

- 1. Have the analysis results over the past 25 years been stable? Yes for 226 of the 235 categories, 96%**
 - Stability would lead to confidence

- 2. Are the results unstable? Yes for 9 of the 235 categories, 4%, All 90th, 95th percentiles, 5 for SSC Endwinding**
 - Instability would lead to caution and the assets own trend would be more important



Summary

- **Proper use of the statistical tables in the Appendix**
 - **For 96% of the results, use with confidence to determine negligible, low, typical, moderate, high and very high**
 - **For 4%, that are unstable, use with caution**
- **In all cases, the trend of a single asset is the most critical**

Yellow flag raising



- Doubling
- High PD
- Investigate

PD is a symptom of failure mechanisms

Thank you

And good luck keeping your machines
running