



**QUALITY
SWITCH**

AN ISO 9001 COMPANY

Functional Life Tests

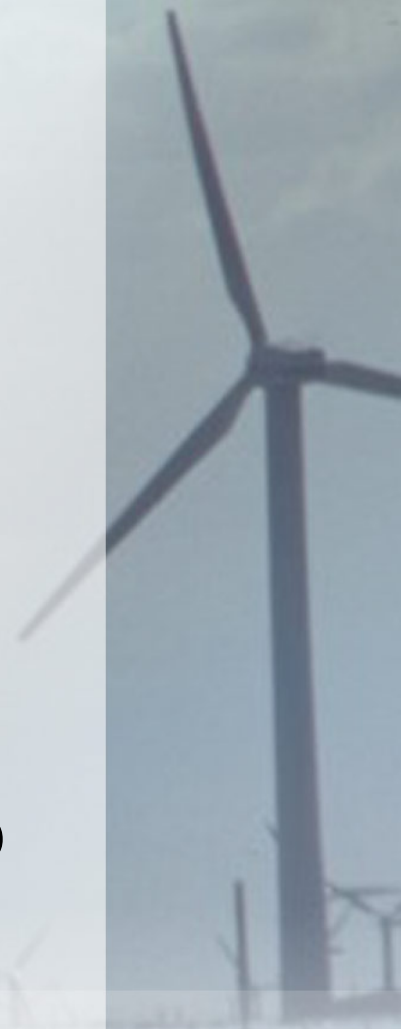
De-energized Tap Changers

Larry Dix

Vice President & General Manager

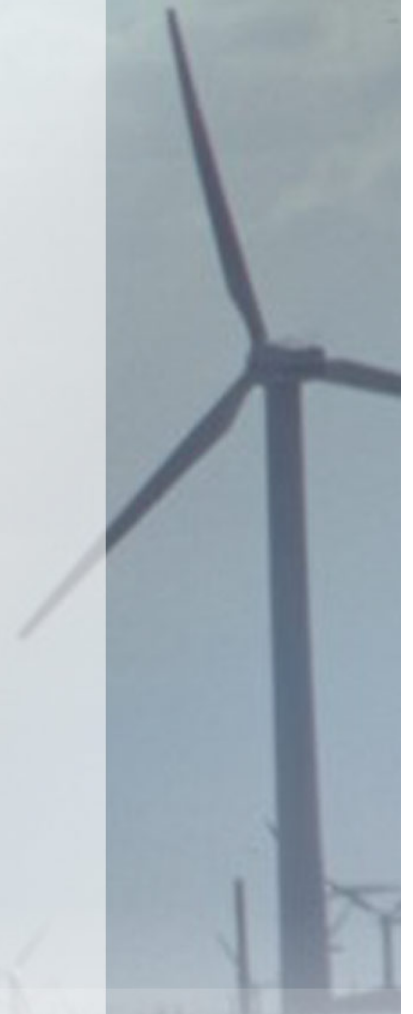
How it started

- **In 1995 began accumulating data on small but significant number of unexplainable DETC failures.**
- **Observed in broad spectrum of tap changers by different manufacturers.**
- **Typical failure time was 12 to 36 months after transformer placed in service.**
- **Typical rated load less than rating of tap changer. (In most cases significantly lower)**



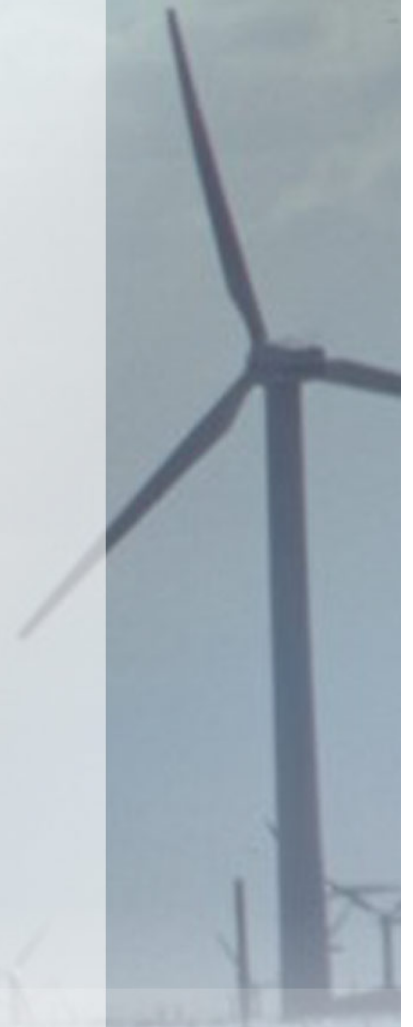
How it started

- **Began more detailed inquiry into conditions of service of failed units.**
- **Observed that most failures were in peaking, pulsing loads:**
 - Rectifier Loads
 - Motor Starting Loads
 - Furnace Supplies
 - Emergency Generator Transformers
- **Observed no failures in utility transformers or units that had more “homogenized” loads.**



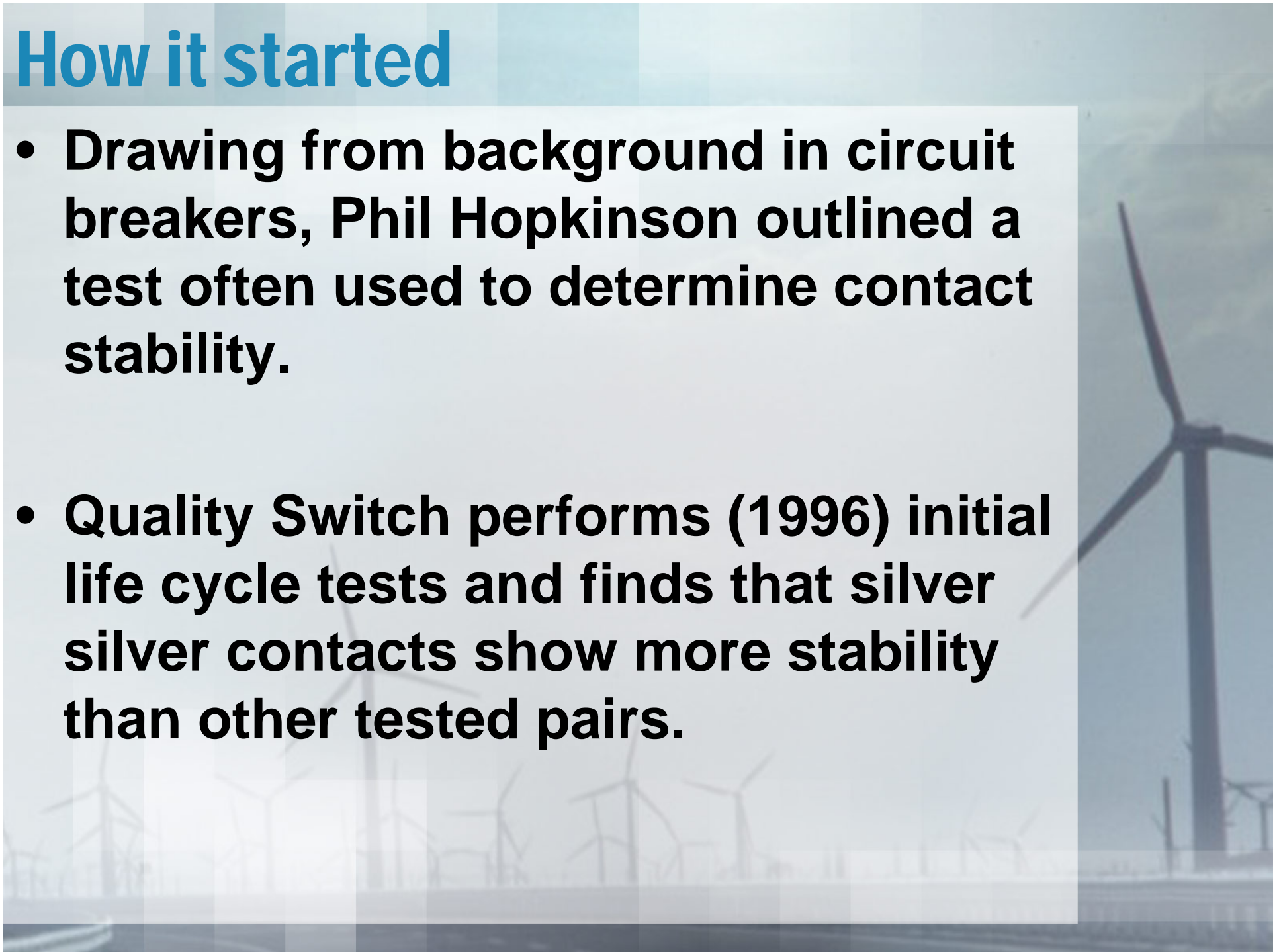
How it started

- **Gas in oil analysis identified failing switches.**
- **Contacts of switches returned for analysis showed extreme contact temperatures.**
- **Replacing units with increased capacity units, even from different manufactures, often resulted in similar failures.**



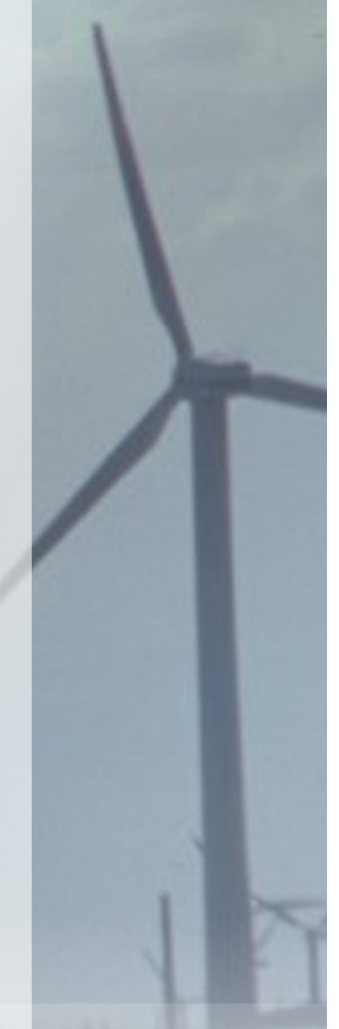
How it started

- **Drawing from background in circuit breakers, Phil Hopkinson outlined a test often used to determine contact stability.**
- **Quality Switch performs (1996) initial life cycle tests and finds that silver silver contacts show more stability than other tested pairs.**



How it started

- **(1997- 2000) Tapchangers modified to have silver silver contacts are installed in troubled (gassing or units with tap changers jumpered out) transformers. Tapchangers were identical to original units EXCEPT plating. To this date, to my knowledge, these units have not experienced any further issues.**



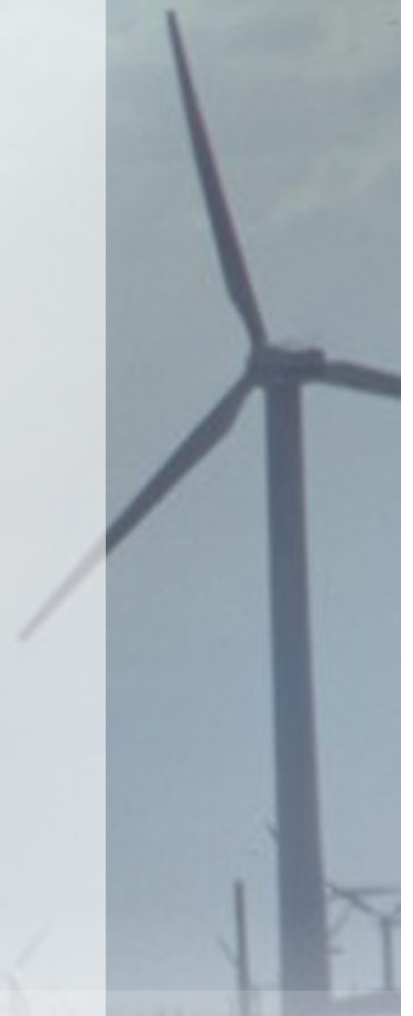
Test Development

- **Earlier discussions have covered the development of test conditions and fundamental logic behind it.**
- **HOWEVER, lost in the discussions have been some fundamental issues:**



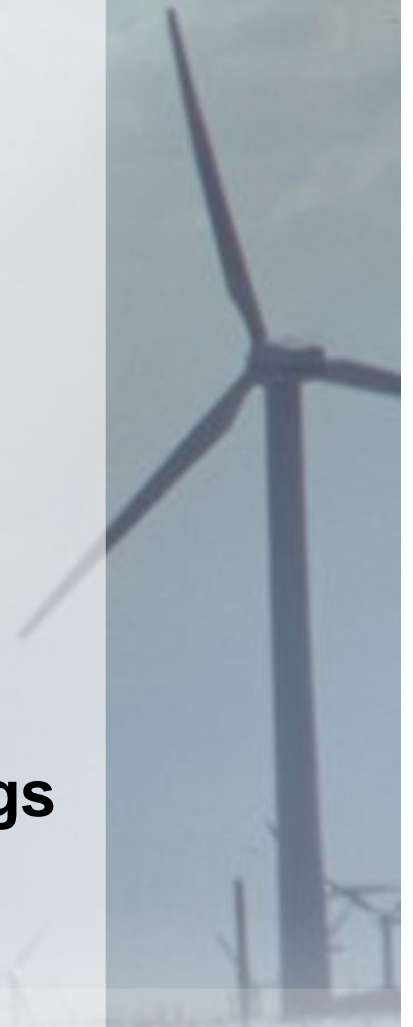
Test Development ~ the goal

- A test that a switch manufacturer could perform that simulates operational conditions in an environment that would produced accelerated results. (30 years in 30 days)
- A test that would indicate the stability of that particular tap changer in service.



Test Development ~ Limitations

- Test was to be on TAP CHANGER decks.
 - Because a number of factors go into contact performance:
 - Contact geometry
 - Contact pressure
 - Base contact material
 - Plating
 - Base contact temperature rise
 - Heat transfer from A spots to surroundings
 - Oil flow across contacts
 - Etc, etc, etc.....

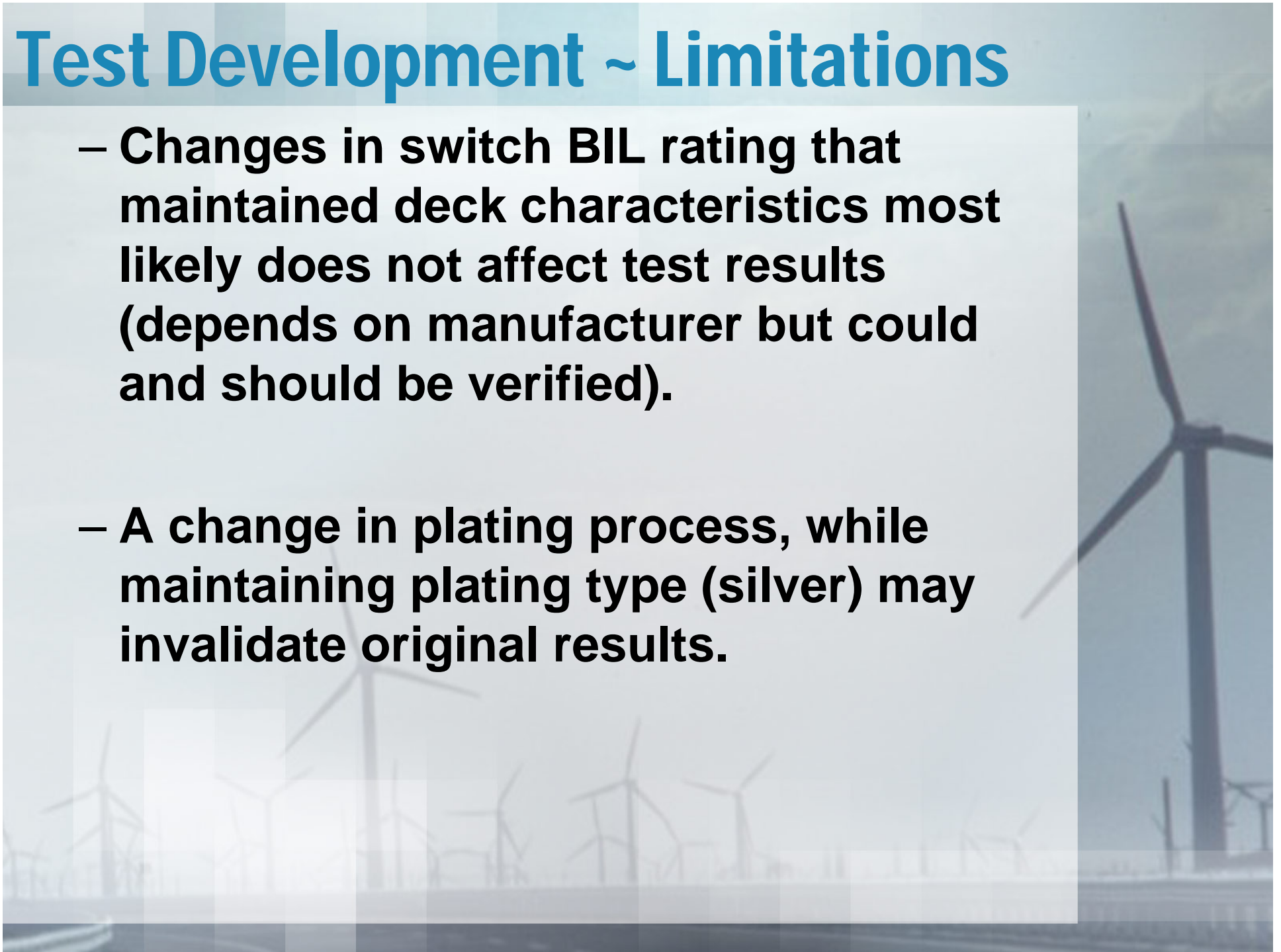


Test Development ~ Limitations

- **Would not be applicable across the board (between manufacturers and between dissimilar models)**
 - **Results of a test on a Quality Switch 200 amp tap changer deck with silver silver contacts would not indicate performance results on a XYZ tapchanger deck with silver silver contacts.**
 - **Results of a test on a Quality Switch 200 amp tapchanger deck would not indicate performance results on a different style or amp rating of Quality Switch tapchanger deck.**

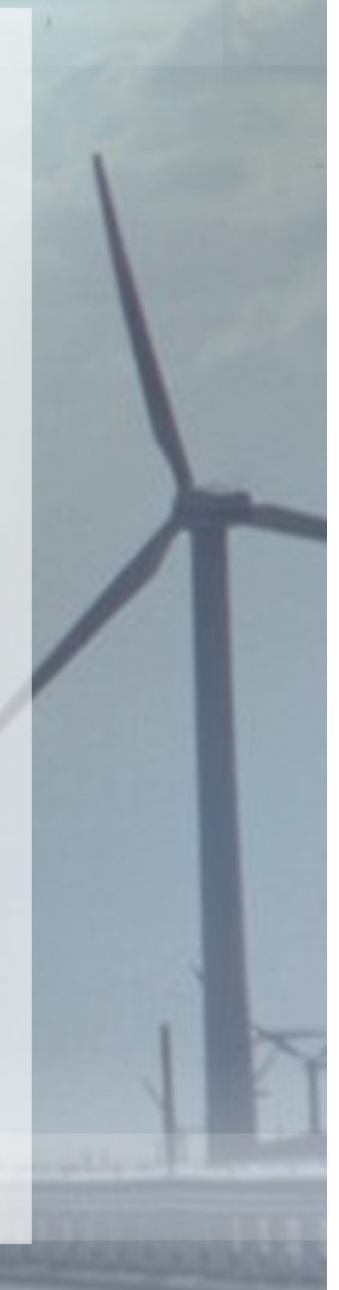
Test Development ~ Limitations

- **Changes in switch BIL rating that maintained deck characteristics most likely does not affect test results (depends on manufacturer but could and should be verified).**
- **A change in plating process, while maintaining plating type (silver) may invalidate original results.**



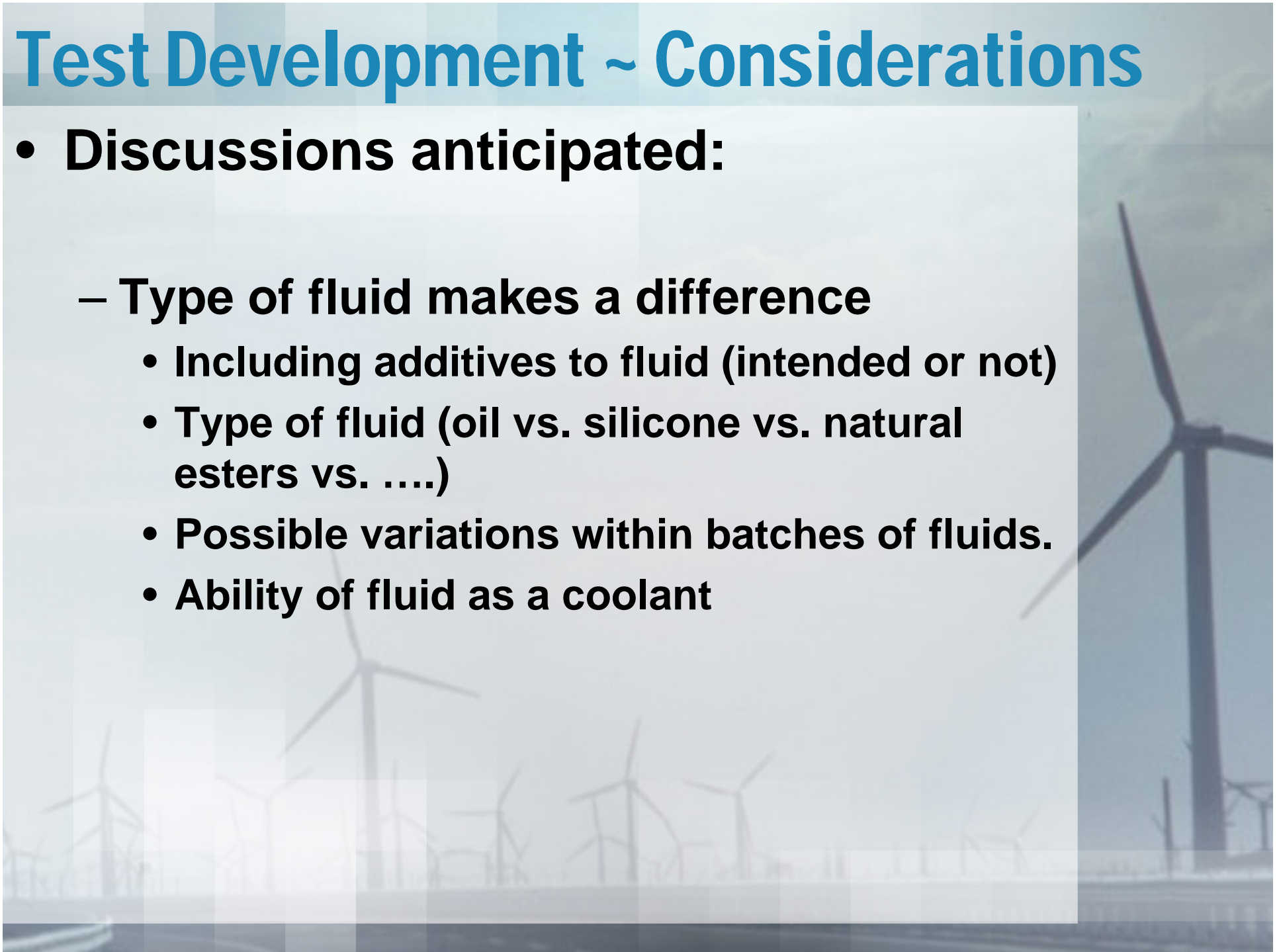
Test Development ~ Considerations

- **Discussions and tests indicated:**
 - **Oil volume must be sufficient to supply necessary chemicals for reaction. In our case, approximately 25 to 30 gallons of fluid used for test on relatively small tap changer. Tank sealed, but not completely isolated.**
 - **Recognized that degradation of insulation in transformer supplies compounds for reaction. Decided to use complete tap changers (not just decks) in order to introduce an aspect of this into the test.**



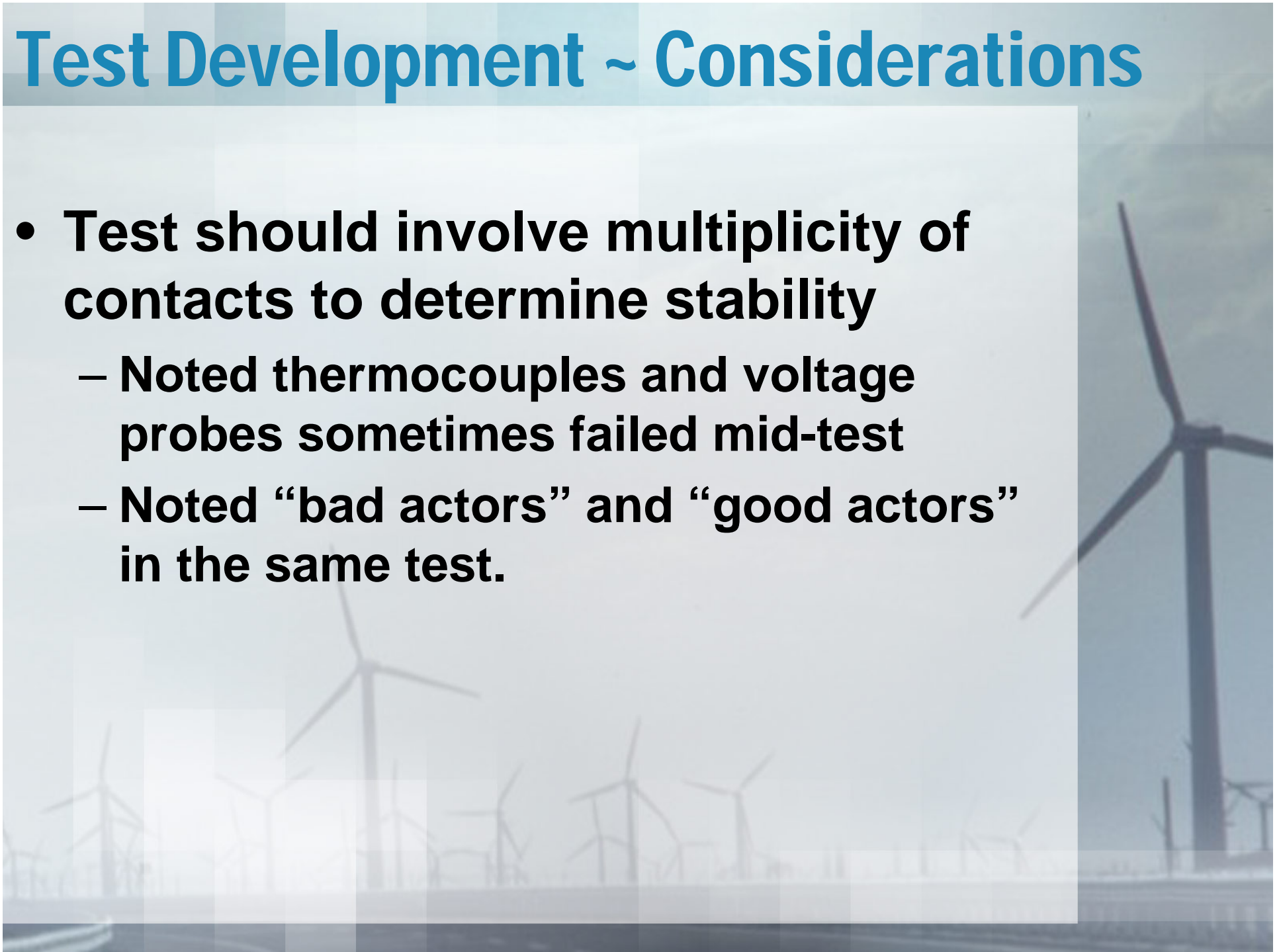
Test Development ~ Considerations

- **Discussions anticipated:**
 - **Type of fluid makes a difference**
 - Including additives to fluid (intended or not)
 - Type of fluid (oil vs. silicone vs. natural esters vs.)
 - Possible variations within batches of fluids.
 - Ability of fluid as a coolant

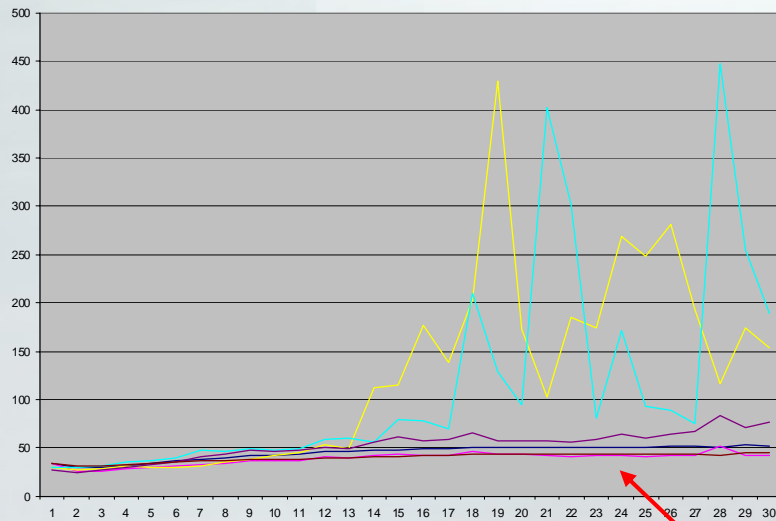


Test Development ~ Considerations

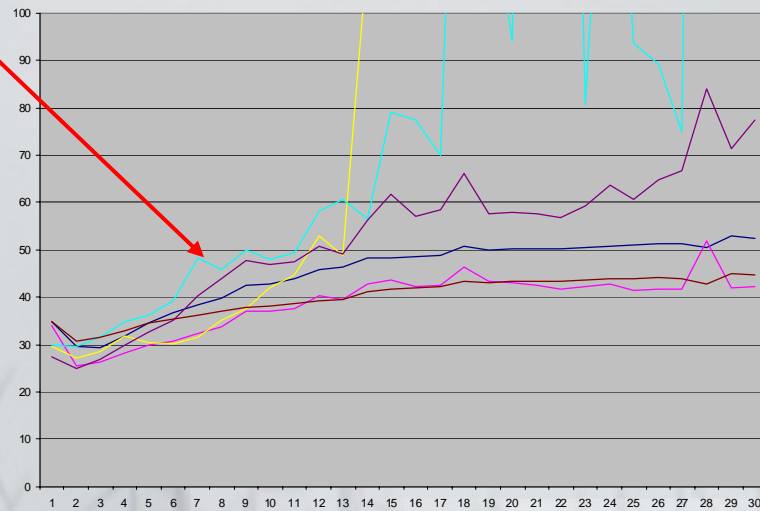
- **Test should involve multiplicity of contacts to determine stability**
 - **Noted thermocouples and voltage probes sometimes failed mid-test**
 - **Noted “bad actors” and “good actors” in the same test.**



Test Development ~ Considerations

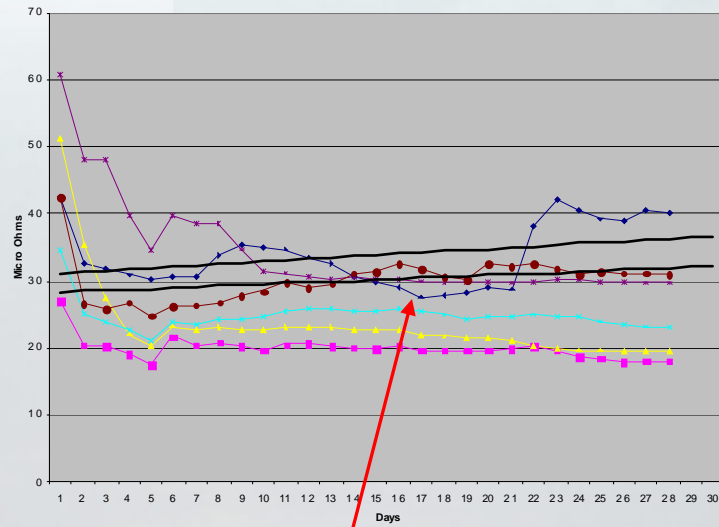
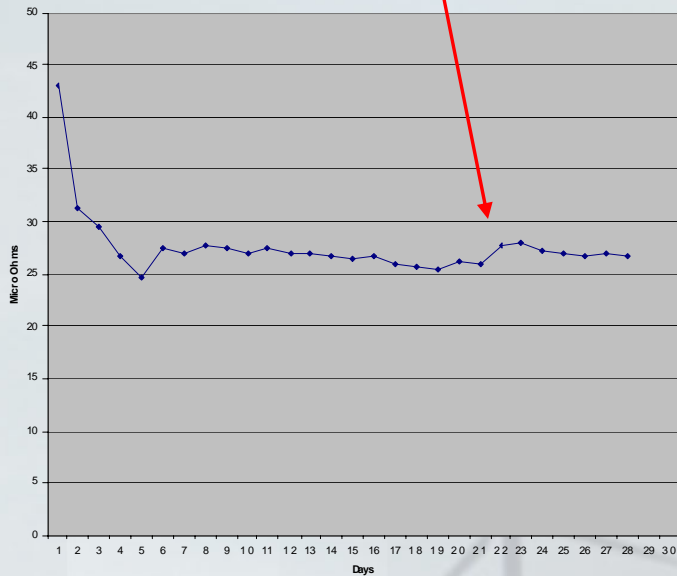


**Really "BAD ACTORS"
can mask overall trends.**



Test Development ~ Considerations

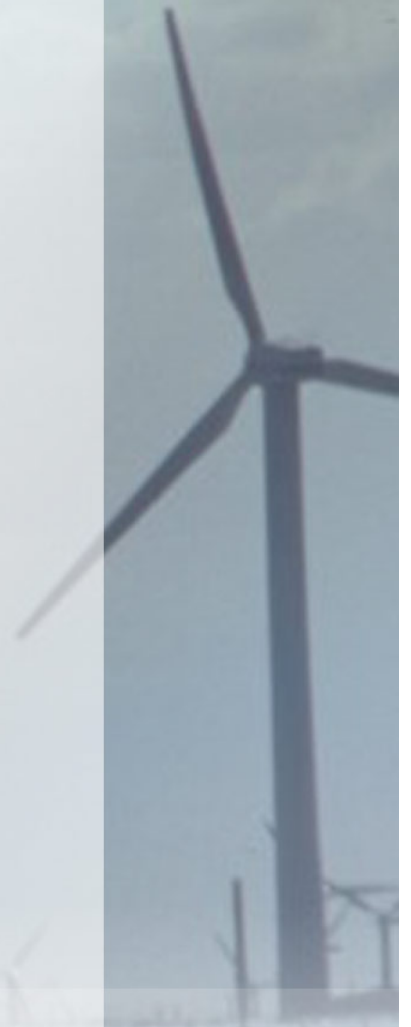
The average is stable.



While some contacts trend up and some trend down

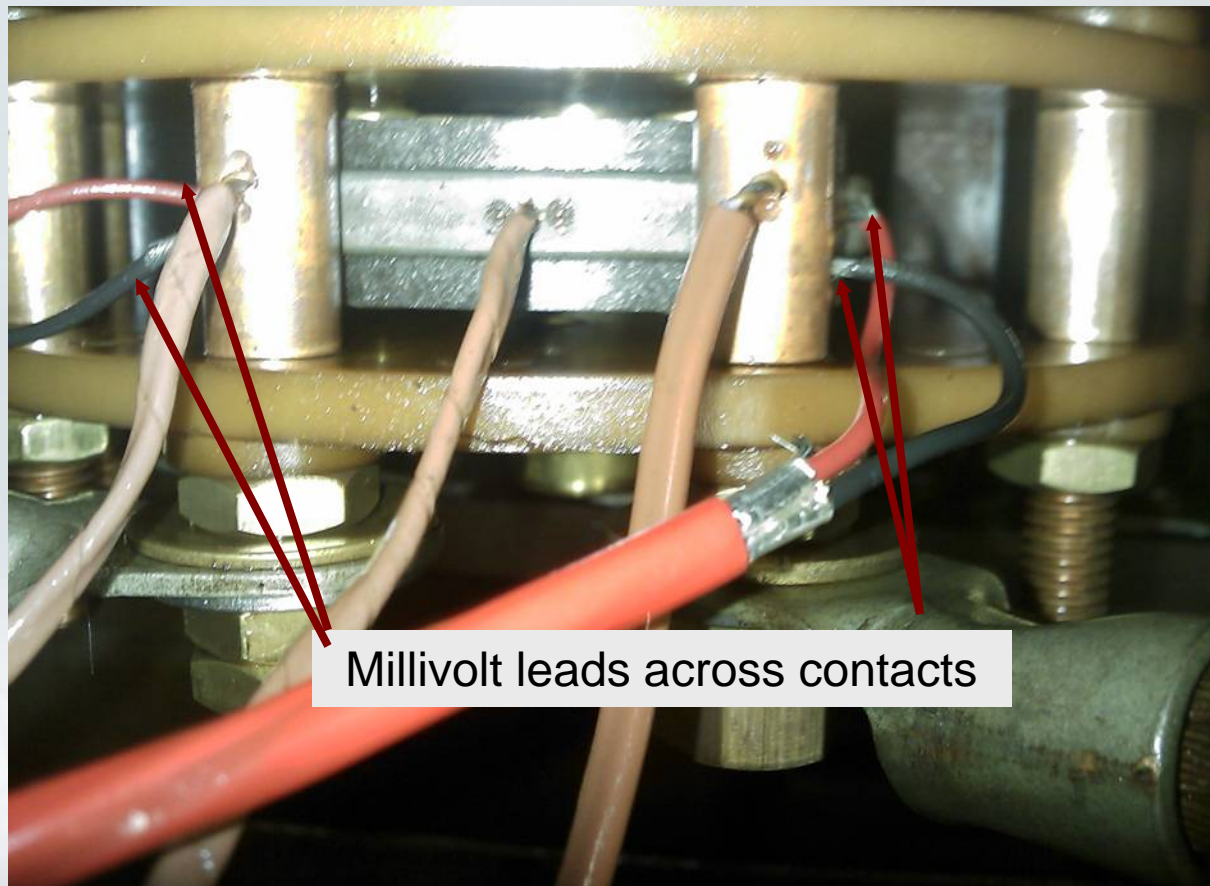
Test Development ~ Considerations

- **Target of 25% maximum increase in average resistance picked as guideline**
 - **Discussions about this number are ongoing.**
 - **Might depend on number of contacts under test at any given time.**
 - **Reasonable to conclude that some “aging” will occur if test simulates 30 years of life.**



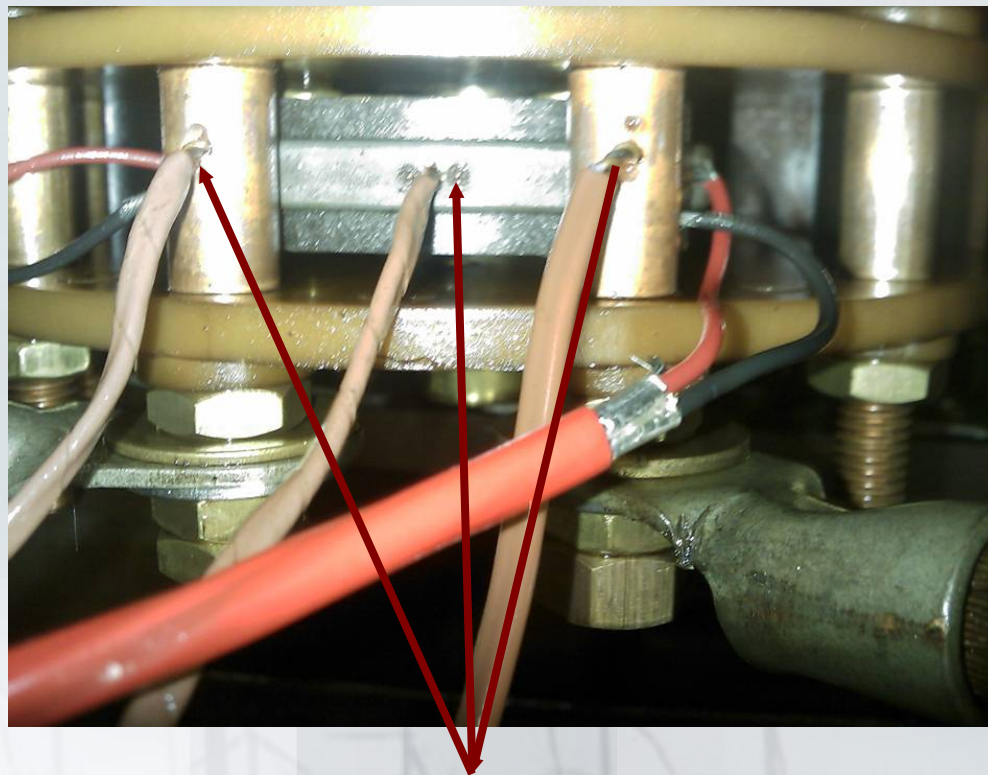
Tapchanger Functional Life Tests-Setup

- **Location of probes vary with switch:**
 - Voltage drop to be measured across contact.



Tapchanger Functional Life Tests-Setup

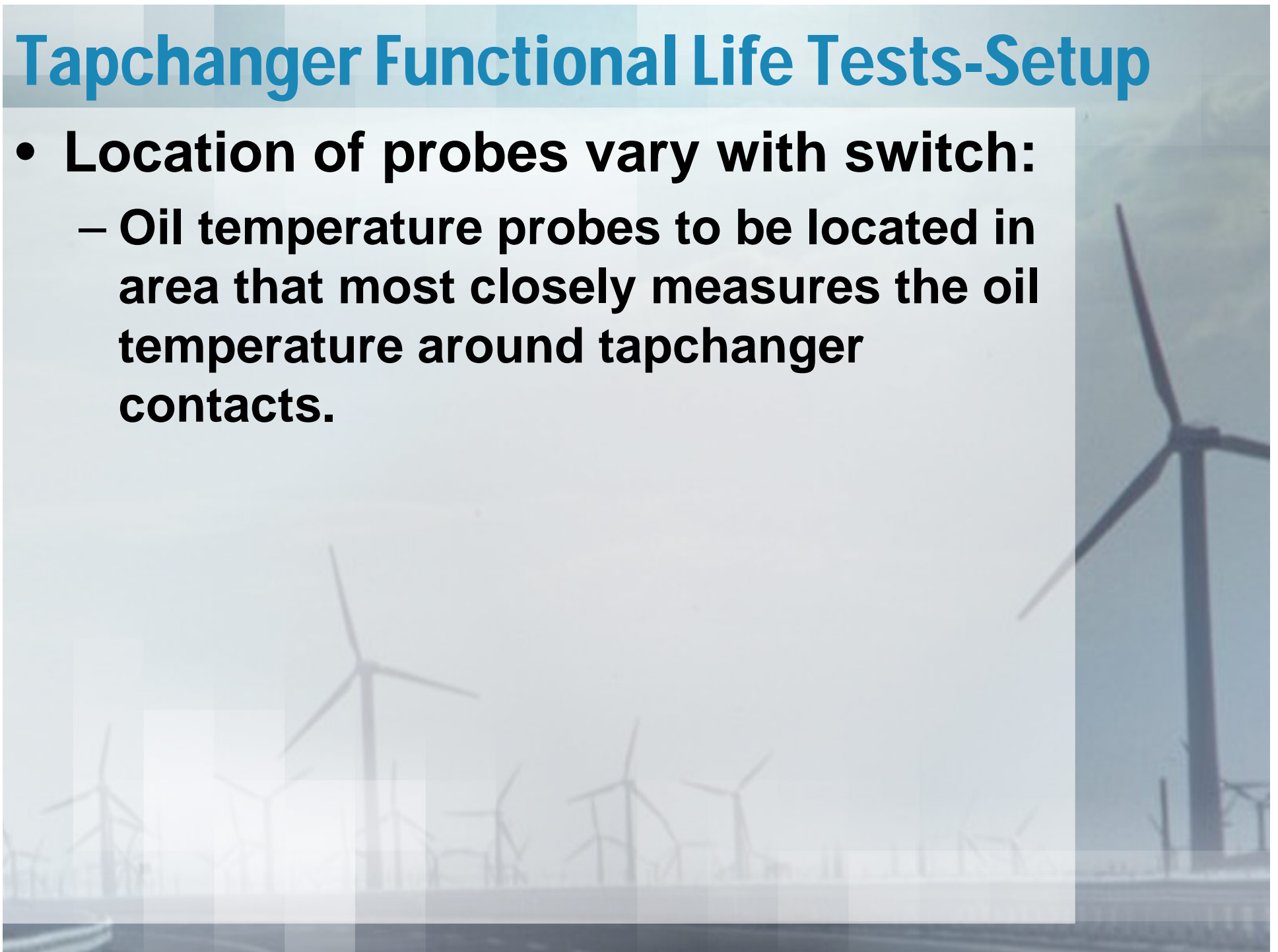
- **Location of probes vary with switch:**
 - Bulk contact temperature probes as appropriate.



Bulk contact thermocouples

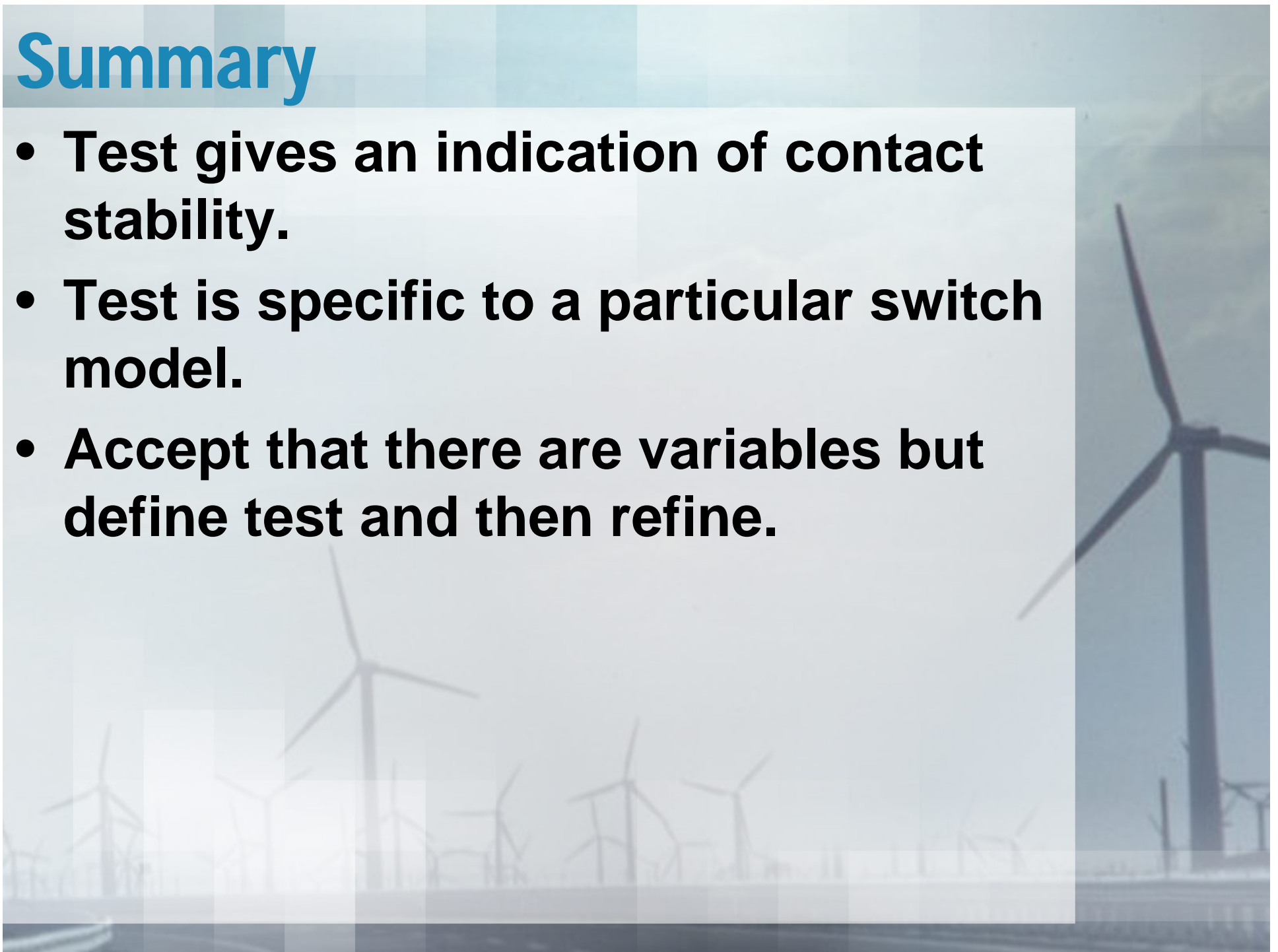
Tapchanger Functional Life Tests-Setup

- **Location of probes vary with switch:**
 - **Oil temperature probes to be located in area that most closely measures the oil temperature around tapchanger contacts.**



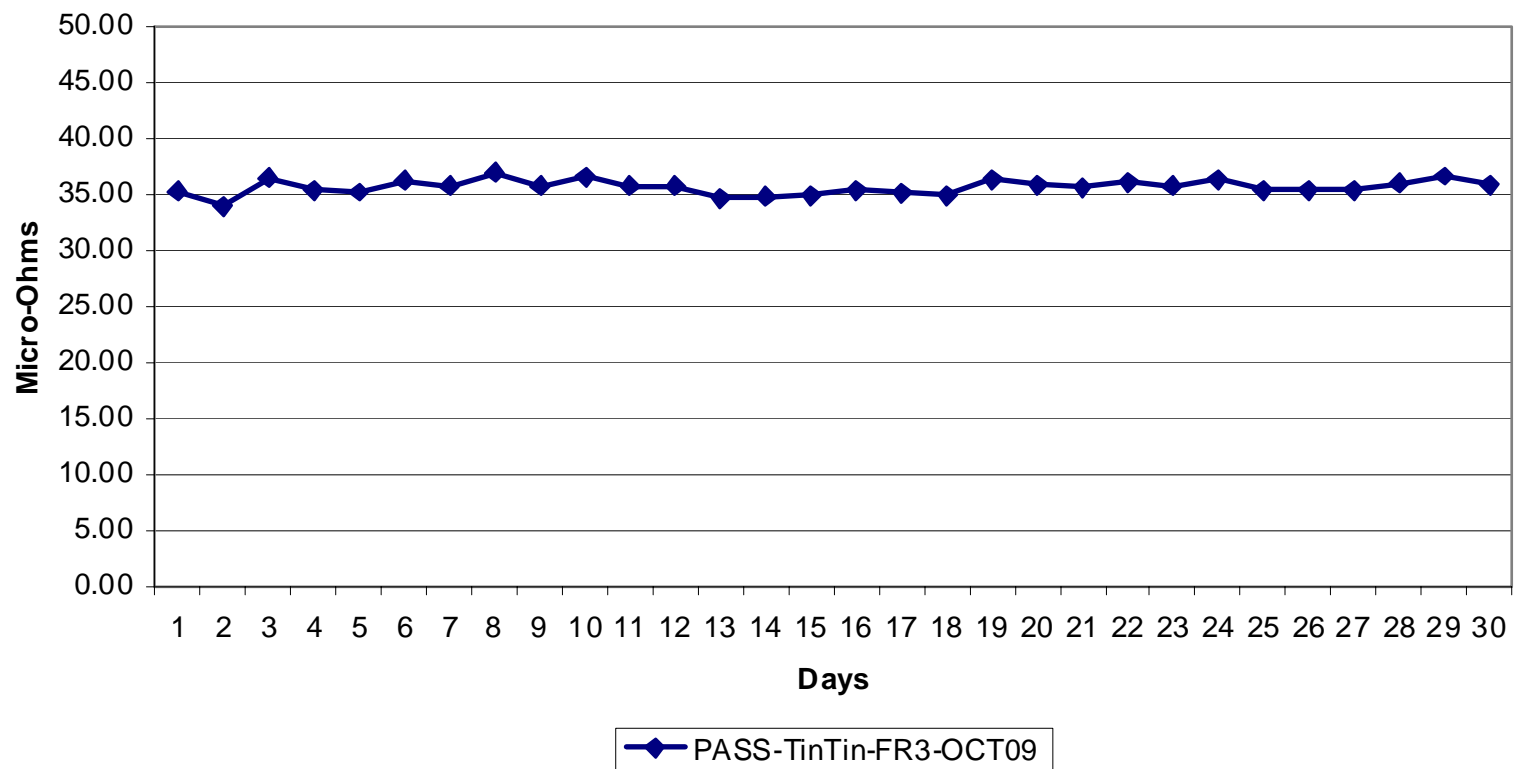
Summary

- **Test gives an indication of contact stability.**
- **Test is specific to a particular switch model.**
- **Accept that there are variables but define test and then refine.**

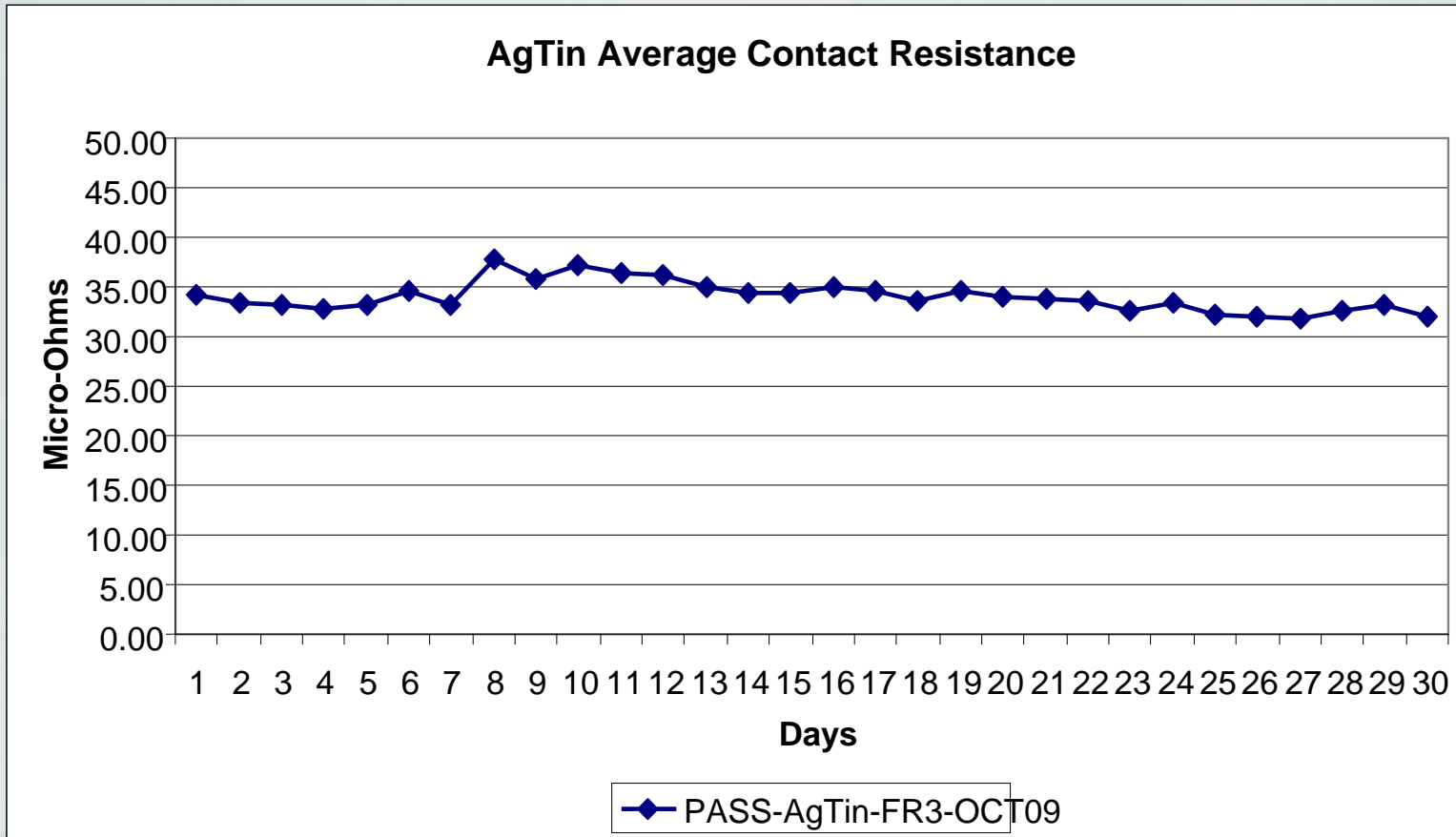


UPDATES

TinTin Average Contact Resistance



UPDATES



UPDATES

Contact Plating / Fluid	Ag-Ag	Ag-Cu	Cu-Cu	Tin-Cu	Ag-Tin	Tin-Tin	Ag-Ni
Oil	PLANNED	FAIL	FAIL			RUNNING	
Silicone	1 pass, 2 fail *check details	FAIL	FAIL	FAIL			FAIL
FR3	PASS	PASS	multiple pass *check details	1 pass, 1 fail *check details	PASS	PASS	PLANNED ?