

# **Tests on Full Scale Power Capacitors using Parallel Resonant Power Supply**

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# Outline

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- **Tests on Full Scale Capacitors**
- **Aging Processes**
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# Introduction

- In the past, overvoltage cycling, endurance and ageing tests could be carried out only on individual elemental capacitor or small kVAr unit.
- With the development of powerfull parallel resonant test apparatus incorporating switching circuitry for achieving fast overvoltage levels for in service requirements for the overvoltage laboratory tests, it has now become possible to test HV full scale power capacitors with software control and data acquisition of the different parameters.
- We shall examine here the advantages of full-scale capacitor testing describing a stringent test procedure as concerns **the rise and decay time** of overvoltage pulses, when doing the overvoltage cycling tests on HV full scale power capacitor.
- Also the aging processes follow up diagnostic tests and the switchgear voltage restriking effects are examine when **switching capacitor current**.

# Parallel Resonant Test Apparatus

**Up to 6.2 MVAR**

**Up to 3.1 MVAR**

## Over voltage

## Capacity

### ■ Cycling

### Test range

### Continuous

50 kV-124 A

**0.4-7.6  $\mu\text{F}$**

50 kV-64 A

40 kV-155 A

**0.6-12.1  $\mu\text{F}$**

40 kV-78 A

33 kV-188 A

**0.93-18.5  $\mu\text{F}$**

33 kV-94 A

20 kV-310 A

**2.7-53.7  $\mu\text{F}$**

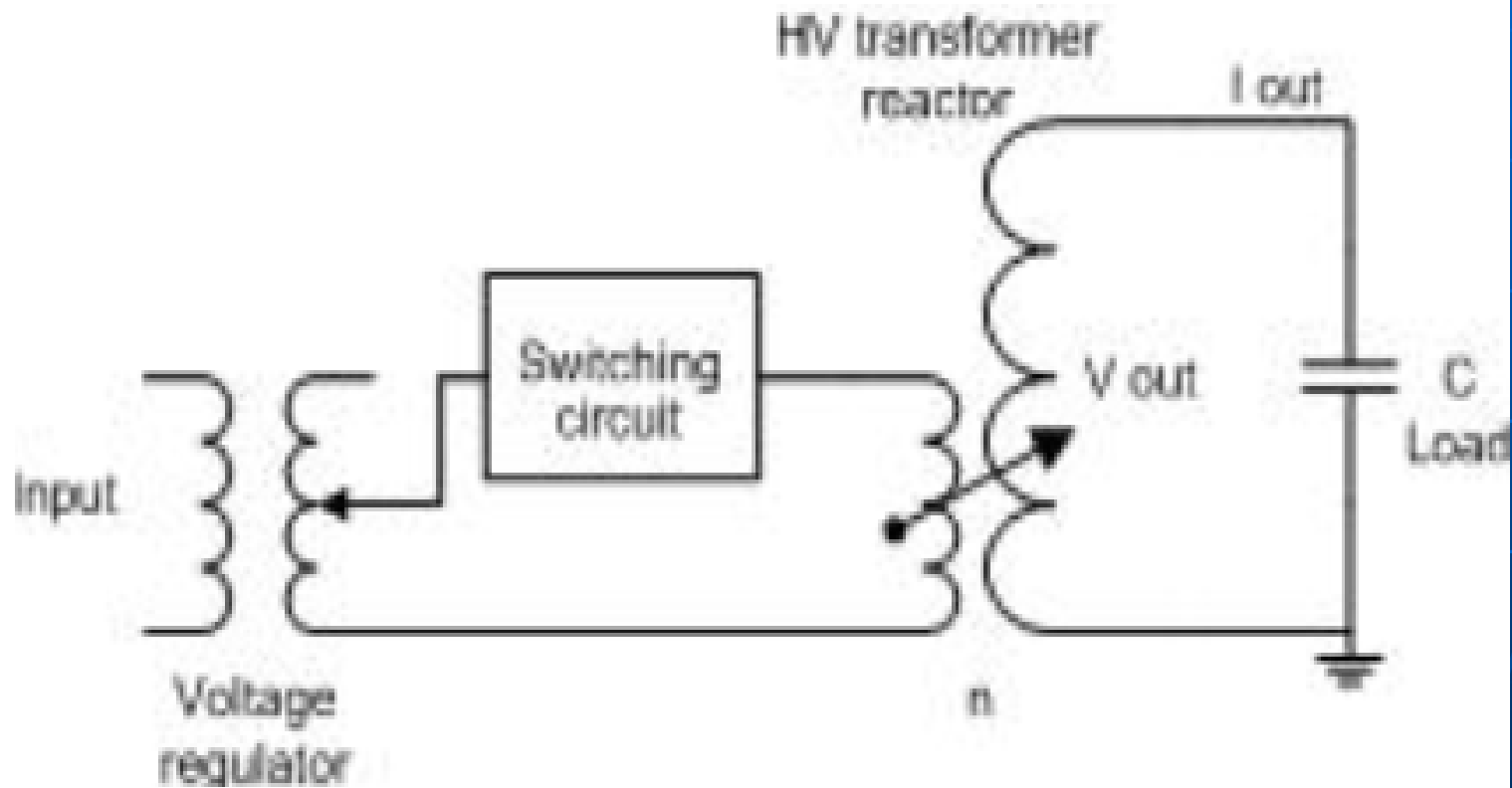
20 kV-155 A

10 kV-390 A

**17.0-218  $\mu\text{F}$**

10 kV-195 A

# Simplify Parallel Resonant Test Apparatus



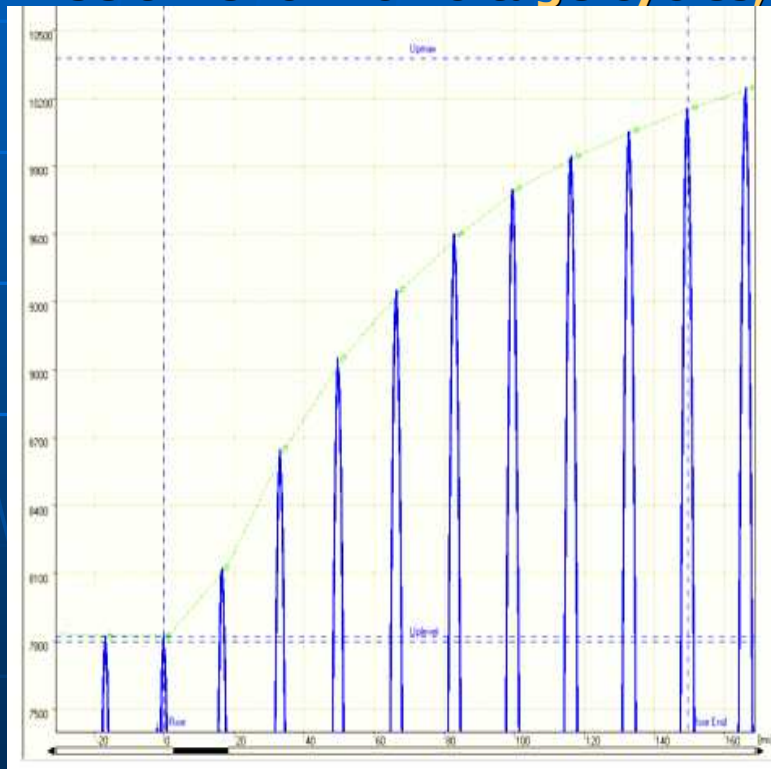
# Tests on Full Scale Capacitors

- Thermal stability test (*IEEE 18 par7.9* )
- Overvoltage cycling test ( *IEC 60871* )
- Aging studies ( *Single and Multi-Stress* )
- Conditioning tests (*IEEE 18* )
- Dissipation factor and capacitance measurements (*IEEE 18* )
- A.C. voltage tests between terminals and container (*IEEE 18* )
- Short circuit discharge tests (*IEEE 18* )
- Voltage decay tests (*IEEE 18* )
- RIV measurements at 1MHz (*IEEE 18* )
- Lightning impulse tests between terminals and container (*IEEE 18* )
- Disconnecting test on internal fuses with load (*IEEE 18* )
- Power switching tests and back to back switching tests between two capacitors
- Ultra - sonic and RF PD measurements

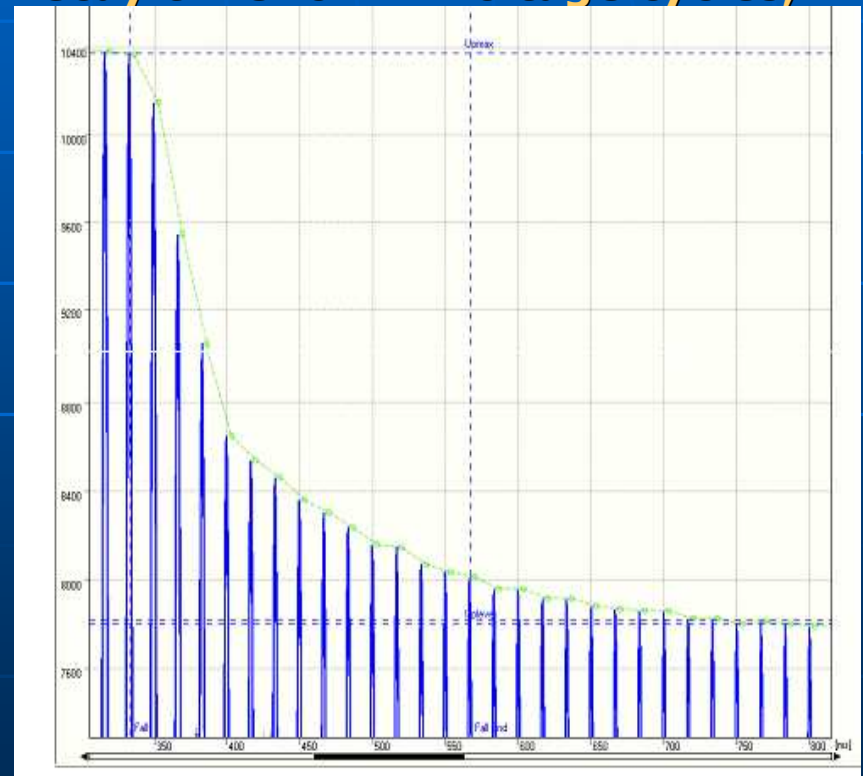
**The capacitor test facility can be used for performing different types of cycling or continuous tests according to different Standards or research programs.**

# Typical Overvoltage Cycling Tests

Rise time for 10 voltage cycles;



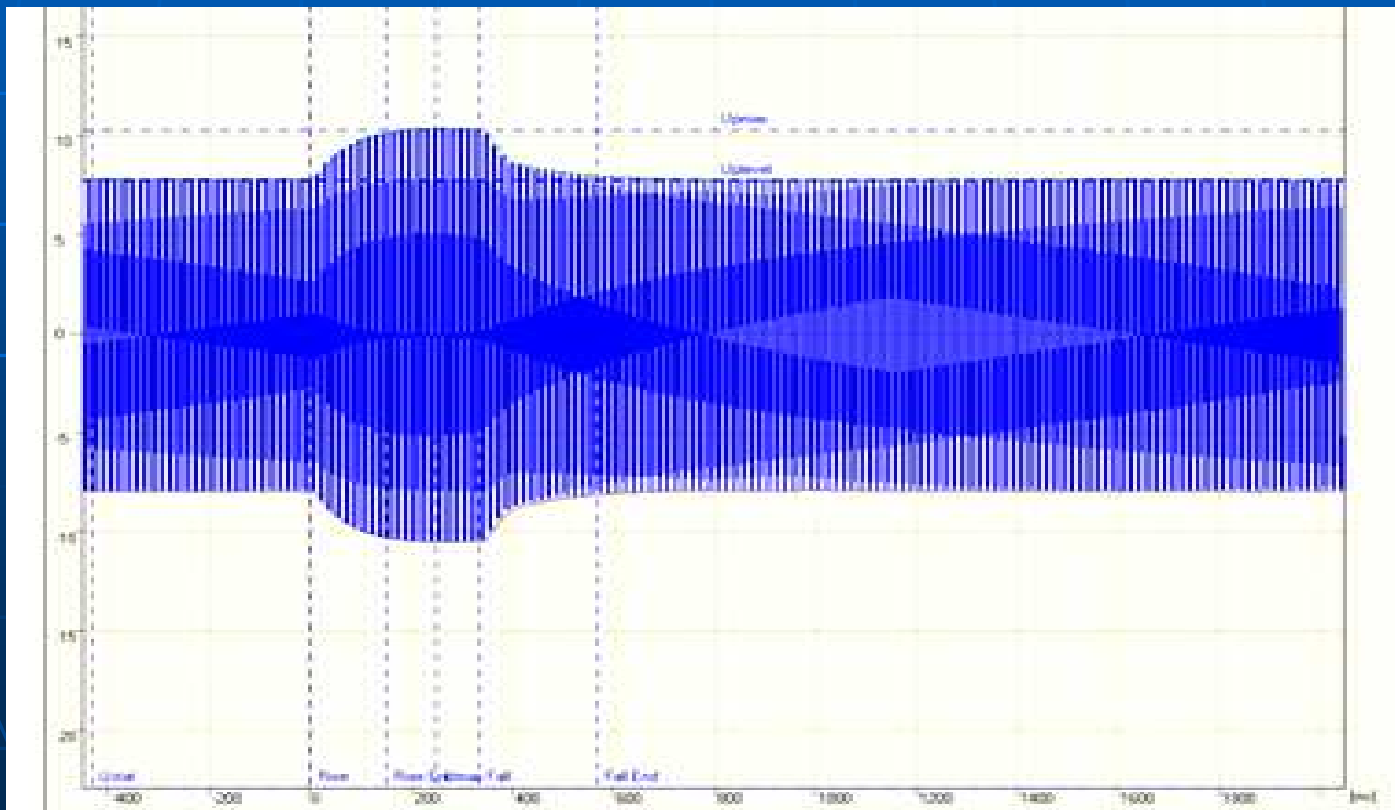
Decay time for 14 voltage cycles;



# Typical Overvoltage Cycling TestS

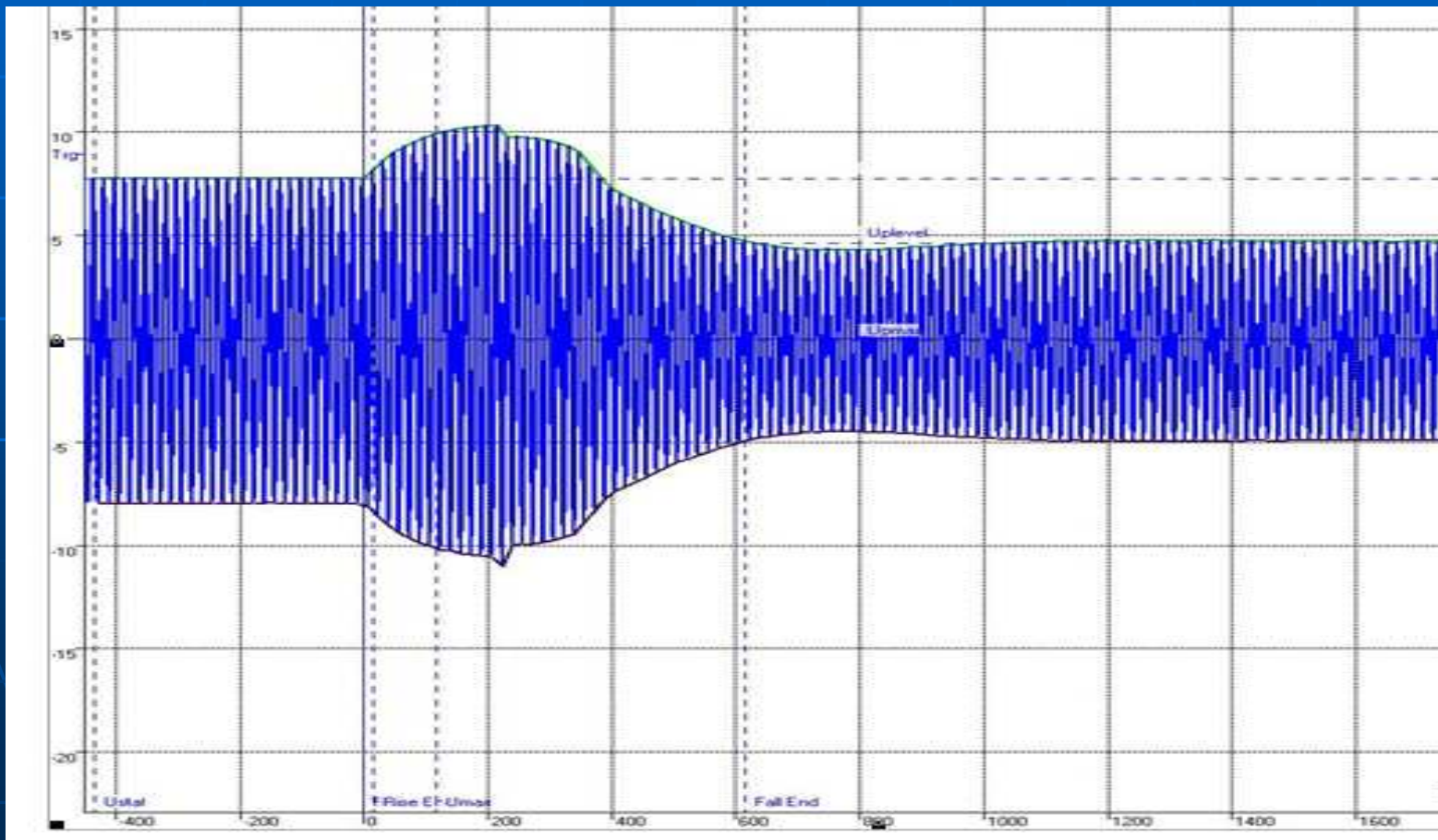
Superimposed overvoltage peak value rise and decay cycles

across a  $113.7\mu\text{F}$ , 2.9 kV fault less full scale series capacitor of 382 kVAR;



# Overvoltage Cycling Tests

Typical distortion in the sinusoidal peak overvoltage magnitude trace across a defective  $113.7\mu\text{F}$ ,  $2.9\text{kV}$  full scale series capacitor of  $382\text{ kVAR}$ ;



# Overvoltage Cycling Tests

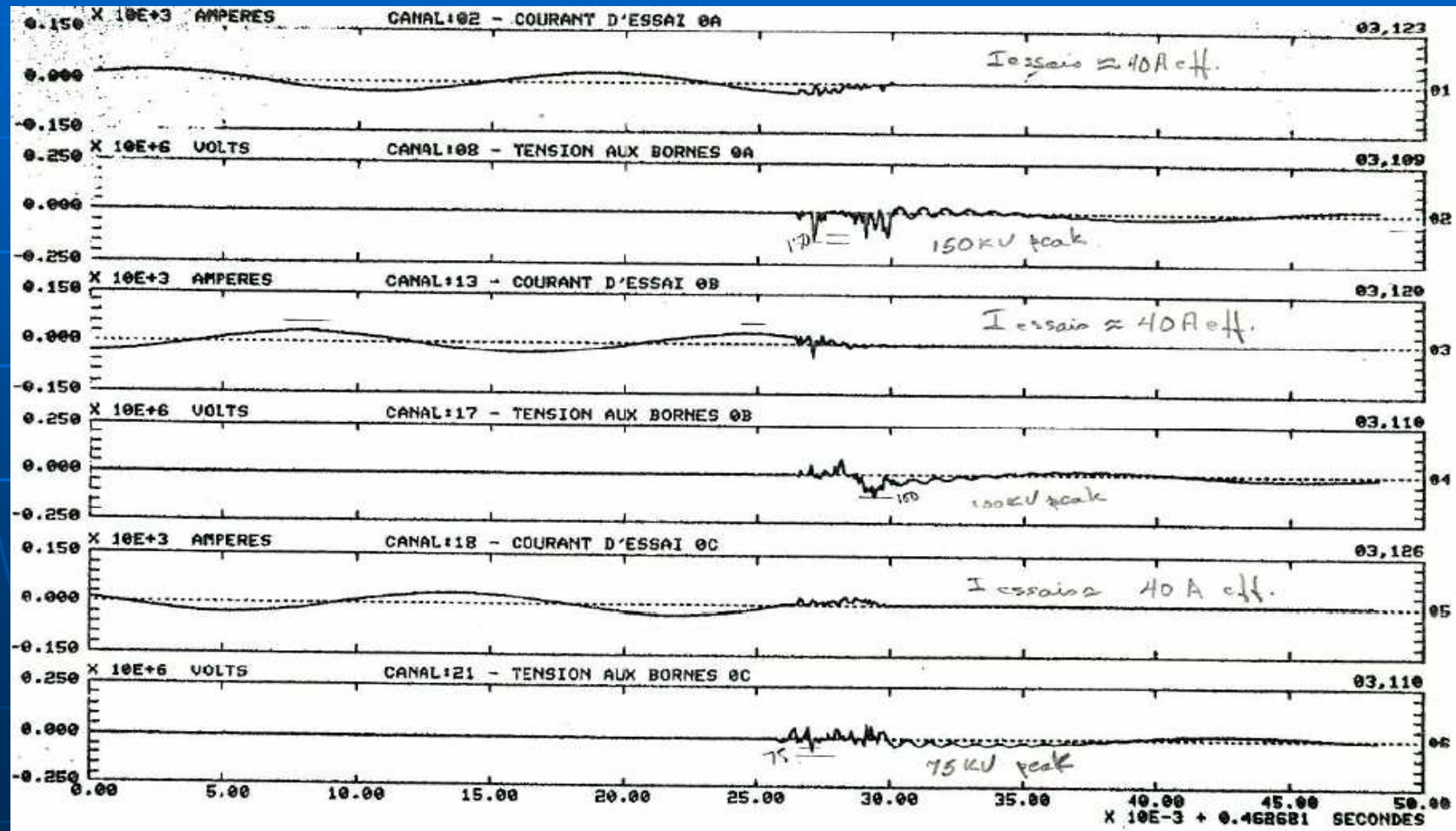
## Data Acquisition Results

Cycle	<u>Ustat</u> [kV]	<u>Umax</u> [kV]	<u>Uplateau</u> [kV]	<u>Cycles</u> rise	Cycles Max	<u>Cycles</u> fall
1	5.92	7.62	5.86	9	9	9
2	5.82	7.58	5.76	10	8	11
3	5.96	7.79	5.95	9	9	13
4	6.05	7.83	6.02	6	12	14
5	5.85	7.65	5.80	9	11	14
6	5.92	7.79	5.92	8	11	13
7	5.84	7.70	5.82	7	11	17
8	5.95	7.80	5.93	7	13	13
9	5.98	7.81	5.93	8	9	11
10	5.81	7.65	5.78	8	10	14

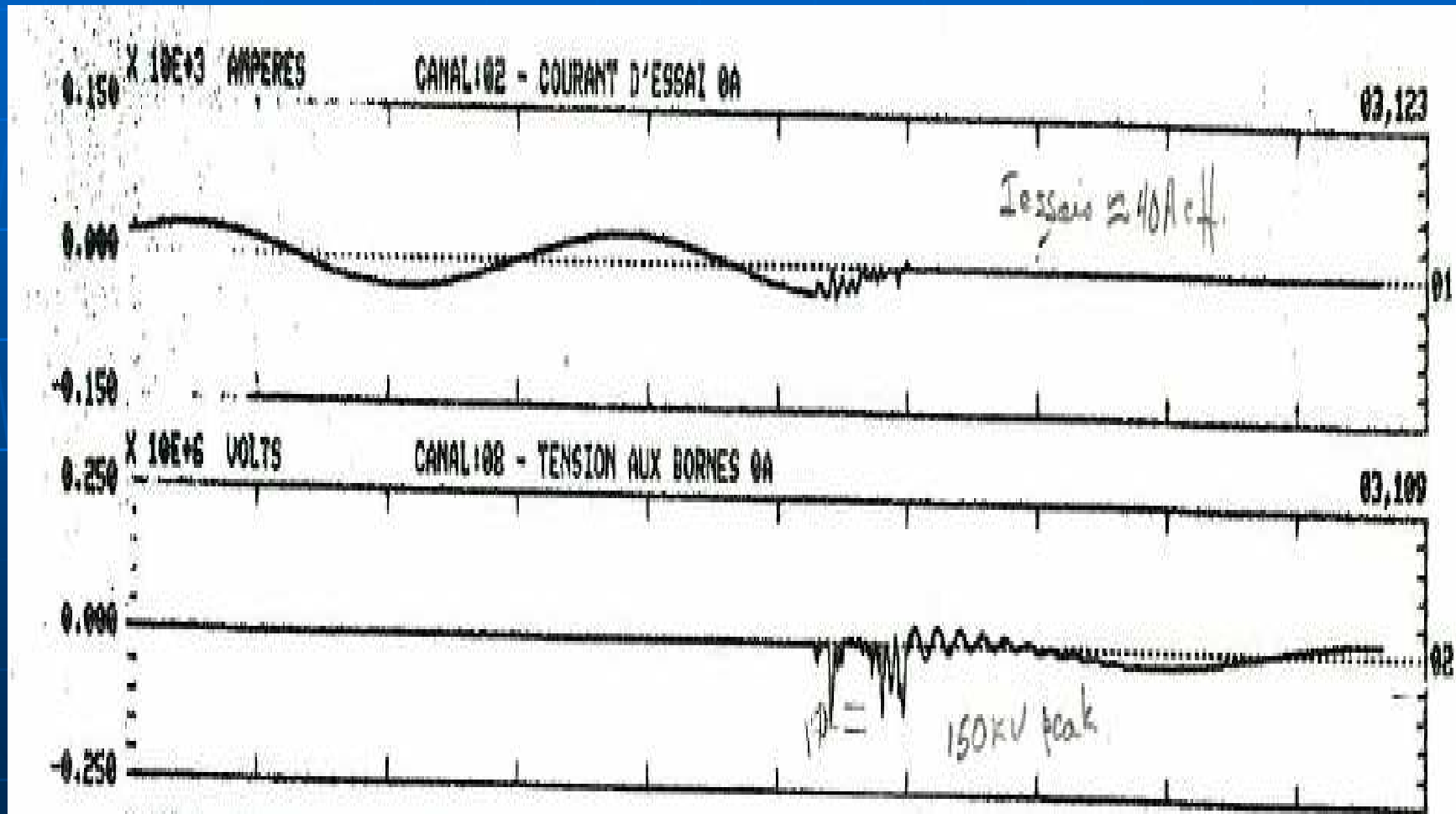
# Aging processes follow up diagnostics

- Dielectric loss, tip-up and capacitance of the solid-liquid insulation system are evaluated using measurements procedures, before, during and after different time of the aging tests.
- Partial discharge losses, Inception and Extinction voltage levels are evaluated using measurements procedures, before, during and after different time of the aging tests.

# Switchgear Restriking Effects, Three Phases Circuit



# Switchgear Restriking Effects, Single Phase Circuit



# Summary

- **The test results have demonstrated that full-scale capacitors can readily be tested, using a parallel resonant test system in conjunction with a switching circuit.**
- **The latter incorporated circuitry provides the overvoltage test levels stipulated by the standards- with even faster rise and fall times of the 60 Hz overvoltage sinusoidal wave magnitude, if required otherwise.**
- **Although the reported test data were obtained with series power capacitors, the use of the same test procedure is not precluded when it is applied on shunt power capacitor specimens.**
- **The methods are now available to evaluate the performance of full scale capacitors in their final completed state rather than just the elemental capacitor units, comprising the overall full scale capacitors.**
- ◆ **Presently tests are already underway on full-scale shunt capacitors, which are intended to be used on Hydro-Quebec's 315 kV and 735 kV transmission lines.**

# Summary

- **Aging of new capacitors during the over voltage tests and the thermal stability tests or aging are evaluated using diagnostics measurements procedures .**
- **Aging of old capacitors coming from the network from the 315 and 735kV Sub-Station are evaluated using diagnostics measurements procedures also.**
- **Voltage restrike during low capacitive current switching may produce over voltage as high as 150kV peak between the 90° and the zero current wave. This overvoltage is added to the nominal ageing of the capacitors bank when evaluating the life of the capacitors.**

# Thank you for your attention

