

Advances in HVDC Technology as applied to the Pacific HVDC Intertie

2008 IEEE PES
Transmission and Distribution
Conference and Exposition

Technical Session –PN05: HVDC System Solutions

April 22, 2008

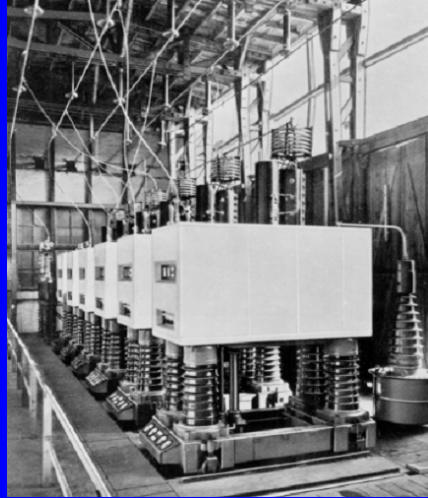
Wayne Litzenberger, FIEEE
High Energy Inc.



Early Mercury Arc Valves

- First HVDC project: Berlin-Charlottenburg 1942
- Moscow 1951
- Gotland 1954
- Pacific HVDC Intertie 1970

Berlin Mercury Arc Valves 1942



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Gotland Mercury Arc Valve



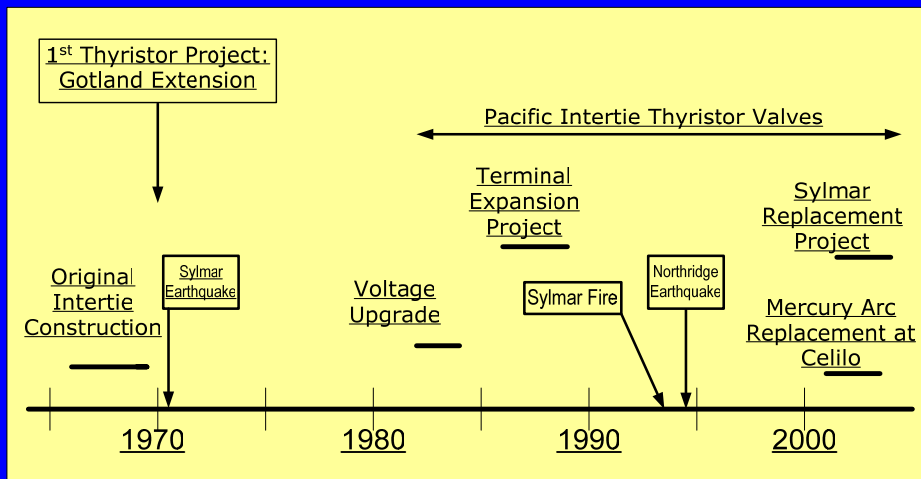
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Pacific HVDC Intertie

1960-1970

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Timeline



DC Test Building



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DC Test Building

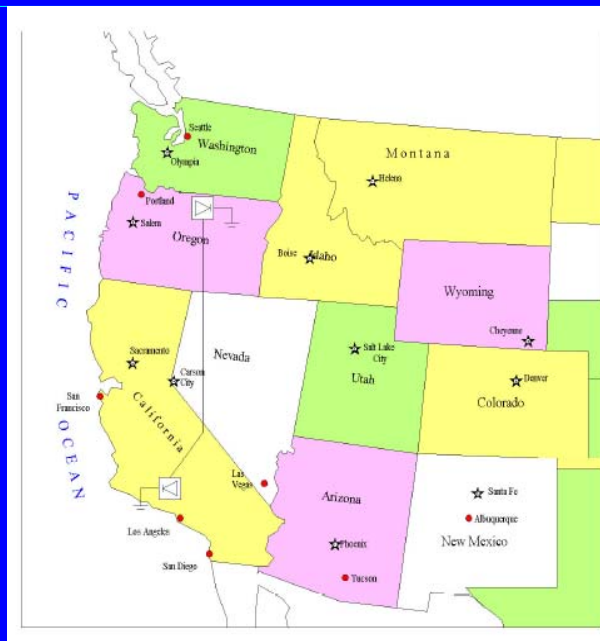


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DC Test Line



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DC Line

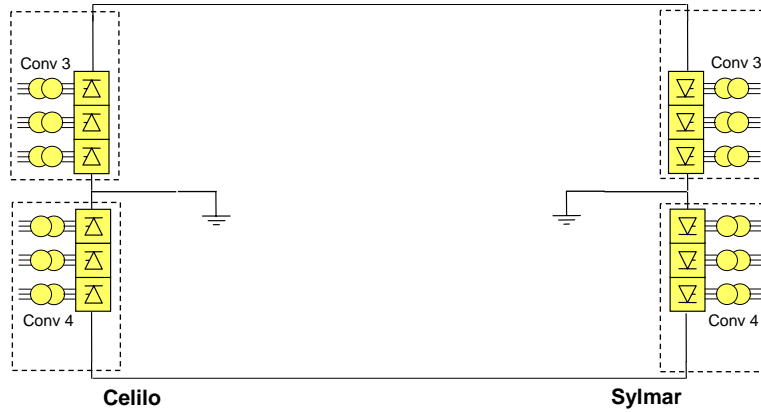


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Celilo Converter Station



133 kV Series Groups



- ±400kV, 1440MW, 3 x 133kV, 1800A Hg-arc valve groups per pole (~1969)
- 160MW, 2000 A inherent continuous current overload capability (~1972)

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Mercury Arc Valves



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Celilo "Museum Piece"



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1970 Sylmar Earthquake

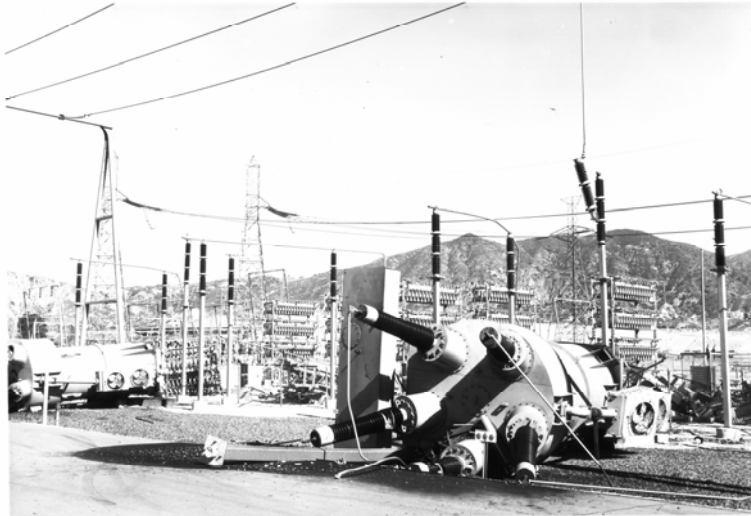
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View of the do filters from just outside the building. Note the fallen dividers, capacitor racks, do transformer, and busbars.



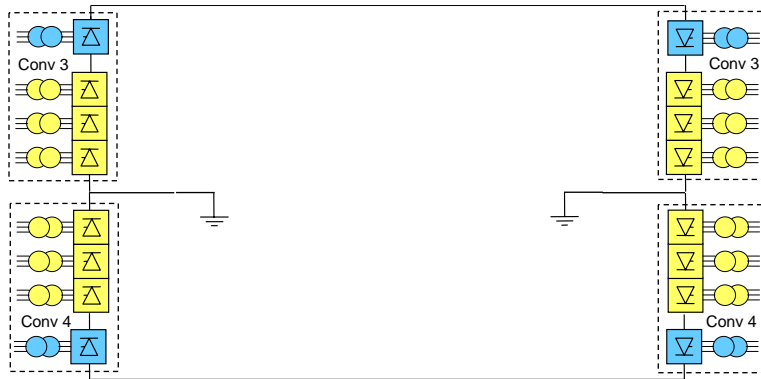
Front view of group 2 valve hall. Note a current divider came down onto the floor bringing down capacitor with it.



General view of the ac filters. Note the fallen 5th 7th, 11th and 15th reactors and capacitor racks.

1980-1990

100 kV Thyristor Groups - 1984



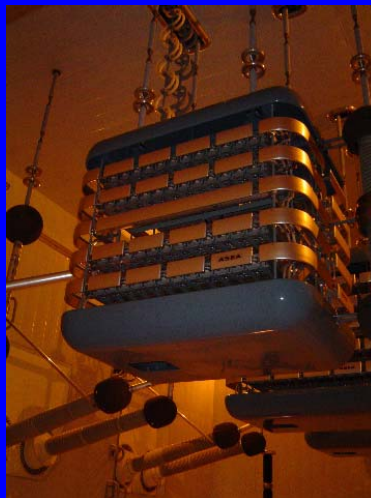
Celilo

Sylmar

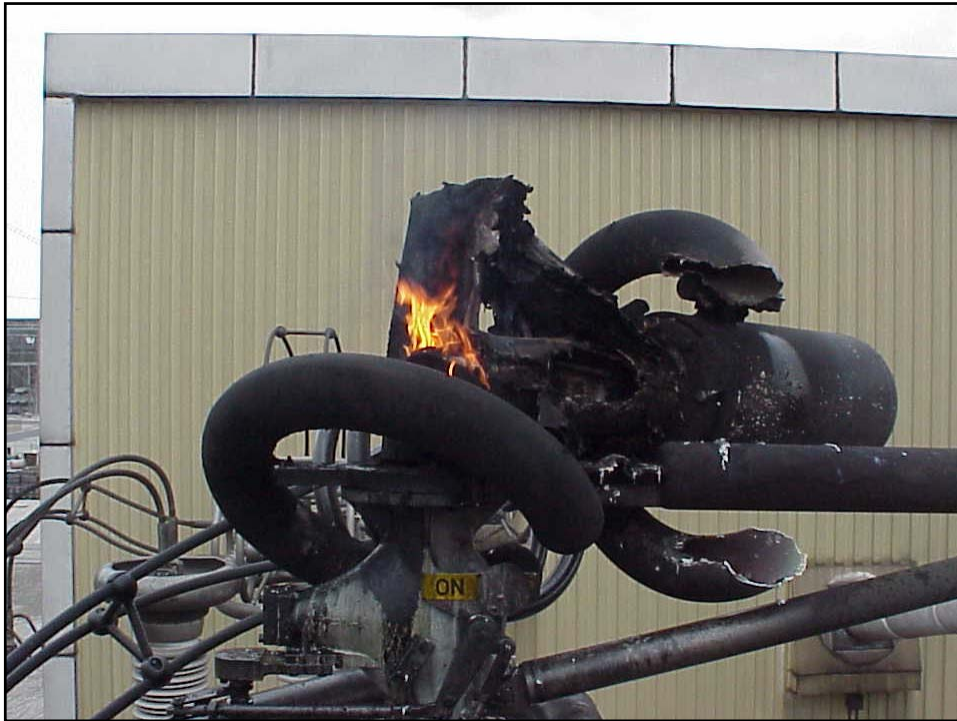
- $\pm 400\text{kV}$, 1440MW, 3 x 133kV, 1800A Hg-arc valve groups per pole (~1969)
 160MW, 2000 A inherent continuous current overload capability (~1972)
- $\pm 100\text{kV}$, 400MW, 1 x 100kV, 2000A thyristor valve group per pole (~1984)

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1984 ASEA 100 kV Valves



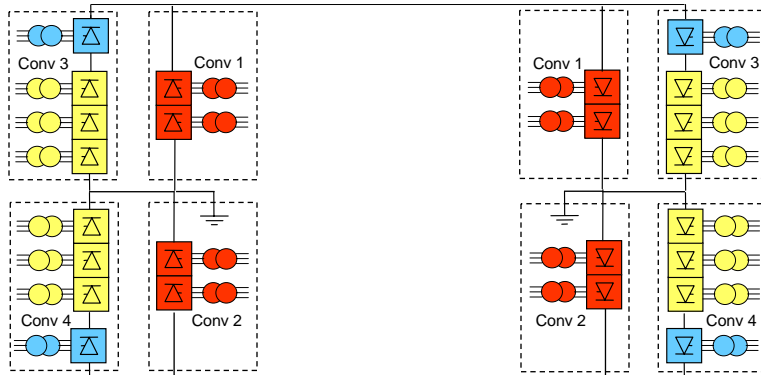
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DC Breaker Tested at Celilo



1100 A Parallel 500 KV Converters



Celilo

Sylmar

- $\pm 400\text{kV}$, 1440MW, 3 x 133kV, 1800A Hg-arc valve groups per pole (~1969)
 160MW, 2000 A inherent continuous current overload capability (~1972)
- $\pm 100\text{kV}$, 400MW, 1 x 100kV, 2000A thyristor valve group per pole (~1984)
- $\pm 500\text{kV}$, 1100MW, 1 x 500kV, 1100A thyristor 12p converter per pole (~1989)

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1989 BBC Valves



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BBC 1100 A 500 kV Valves



Pacific HVDC Intertie 1990-2000

Celilo Demonstration Valve 1997

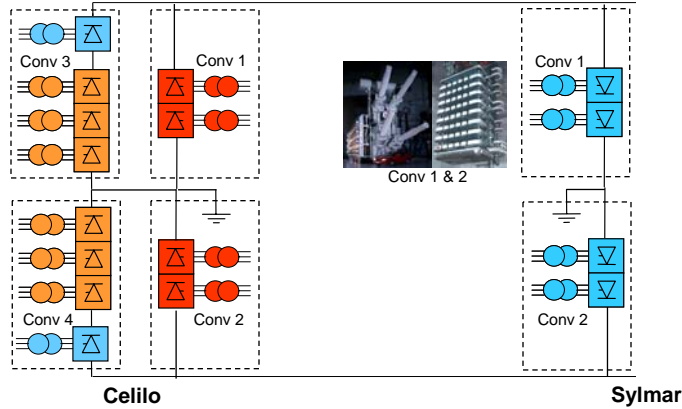


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Pacific HVDC Intertie 2000 +

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Pacific DC Intertie Replacement



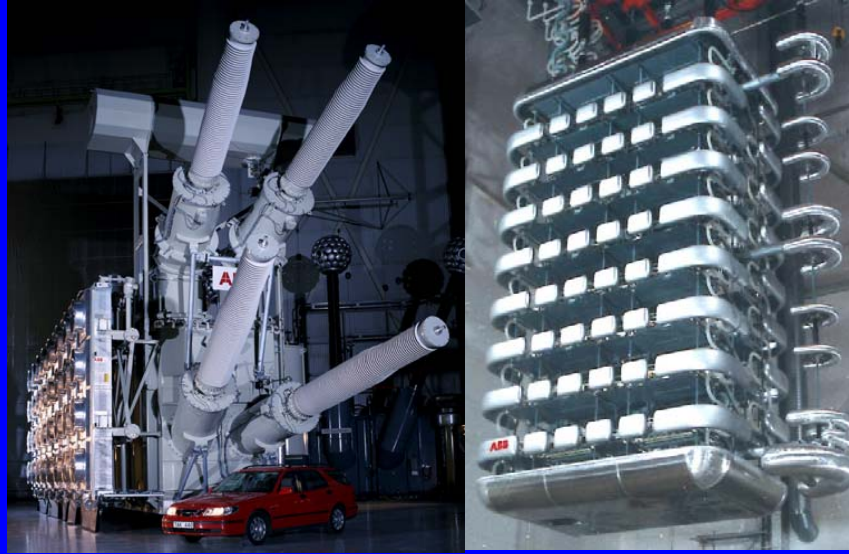
- 2003 Replace 3 Hg-arc valve groups per pole at Celilo with thyristor valves
 - 2004 Replace 1100MW converters 1 & 2 at Sylmar with new 3100 MW converters
- Retire converters 3 & 4 at Sylmar

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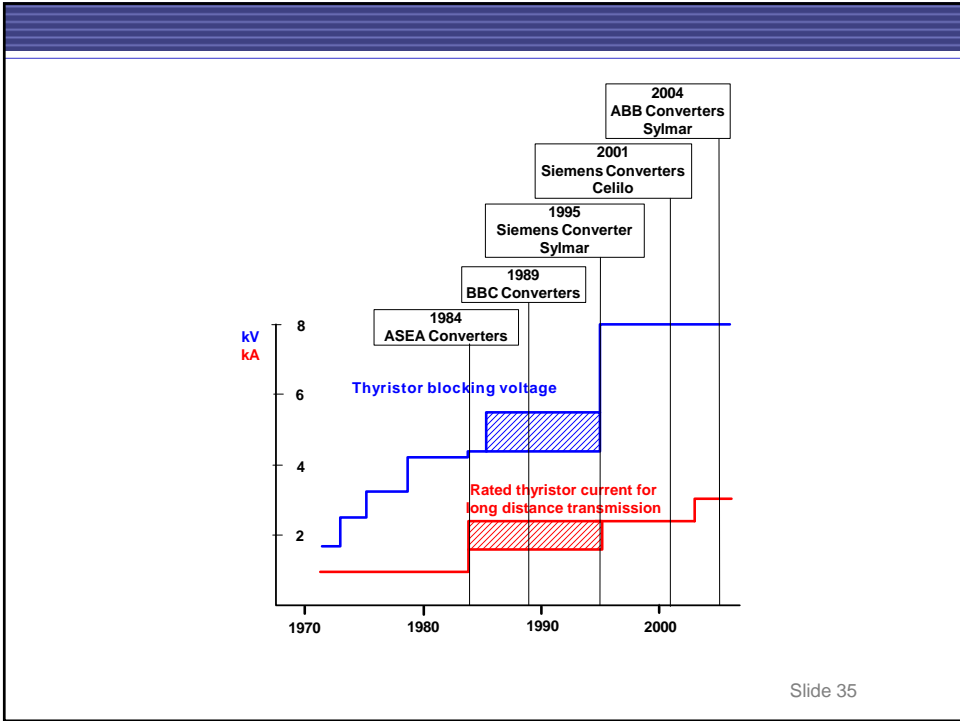
Thyristor Replacement Valves at Celilo



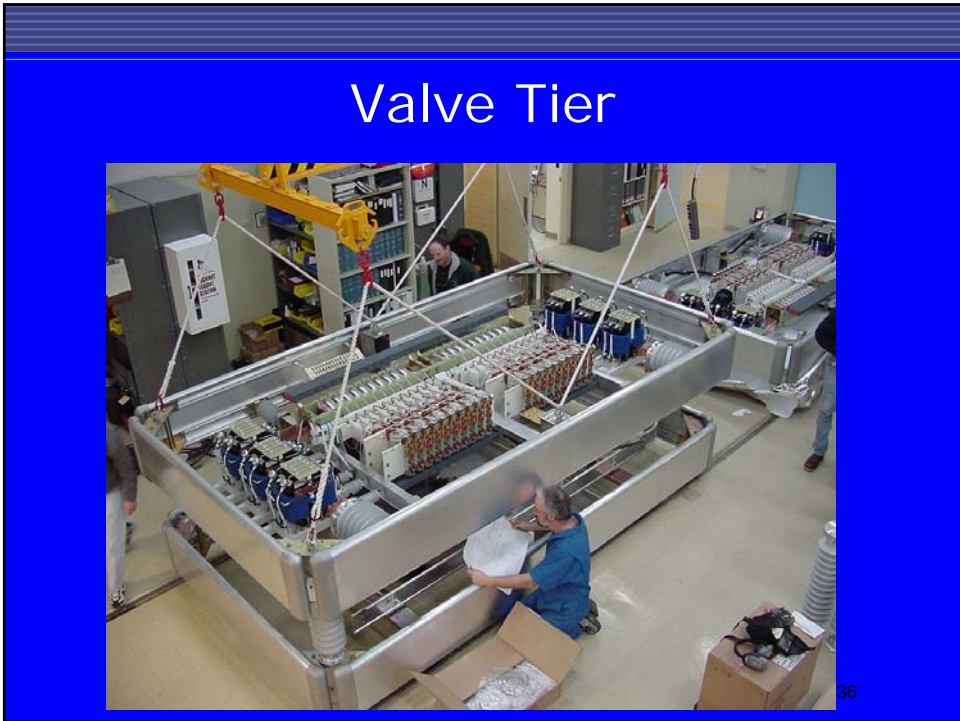
Sylmar Replacement Project



Valve Technology



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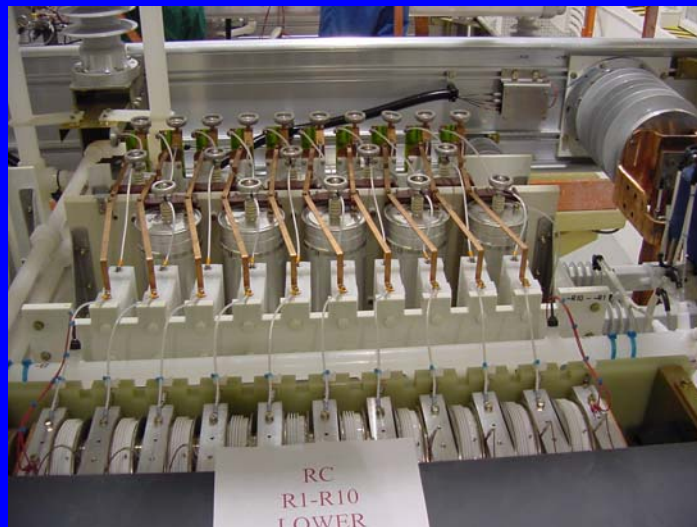
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Valve Components



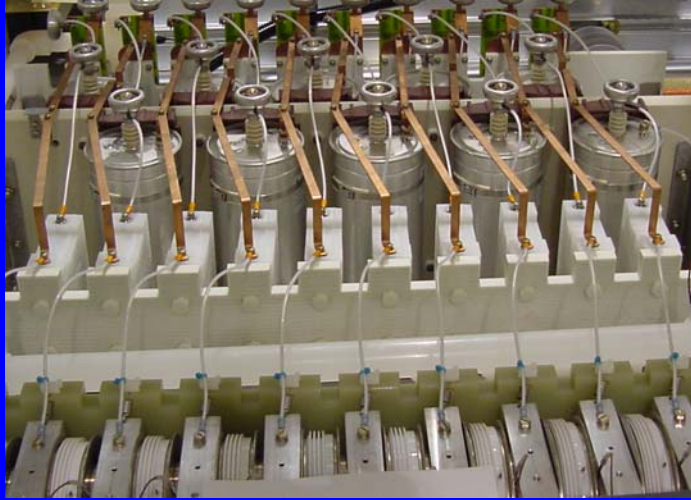
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Valve Components



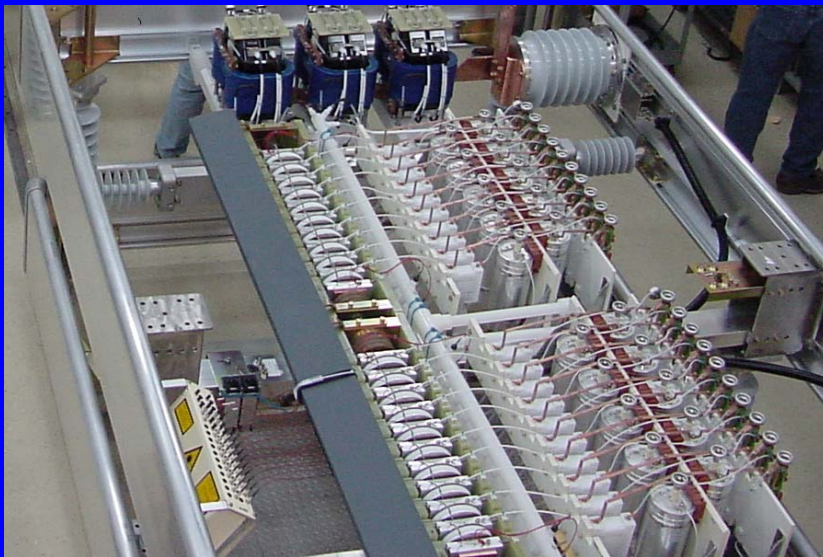
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Valve Components



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Valve Tier



High Voltage Testing



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Materials for Fire Resistance



HVDC Technology

- Mercury Arc Valves
- Thyristor Valves
- Water Cooling
- Electrical or Light Triggering
- Multiterminal Transmission
- Voltage Source Converters
- 800 KV Transmission