EPA Conference on the SF_6 and the Environment: Emission Reduction Strategies

Electrical Insulation Performance of Extremely Small Amount of SF_6 in N_2 Mixture and the SF_6 Reduction Rate for Electric Power Apparatus

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Professor Dr. Eng. Hitoshi OKUBO
Dept. Electrical Engineering, School of Engineering, Nagoya University
Address : Furo-cho, Chikusa-ku, Nagoya, 464-8603 Japan
TEL : +81-52-789-3625 FAX : +81-52-789-3141
e-mail : okubo@nuee.nagoya-u.ac.jp

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Abstract:

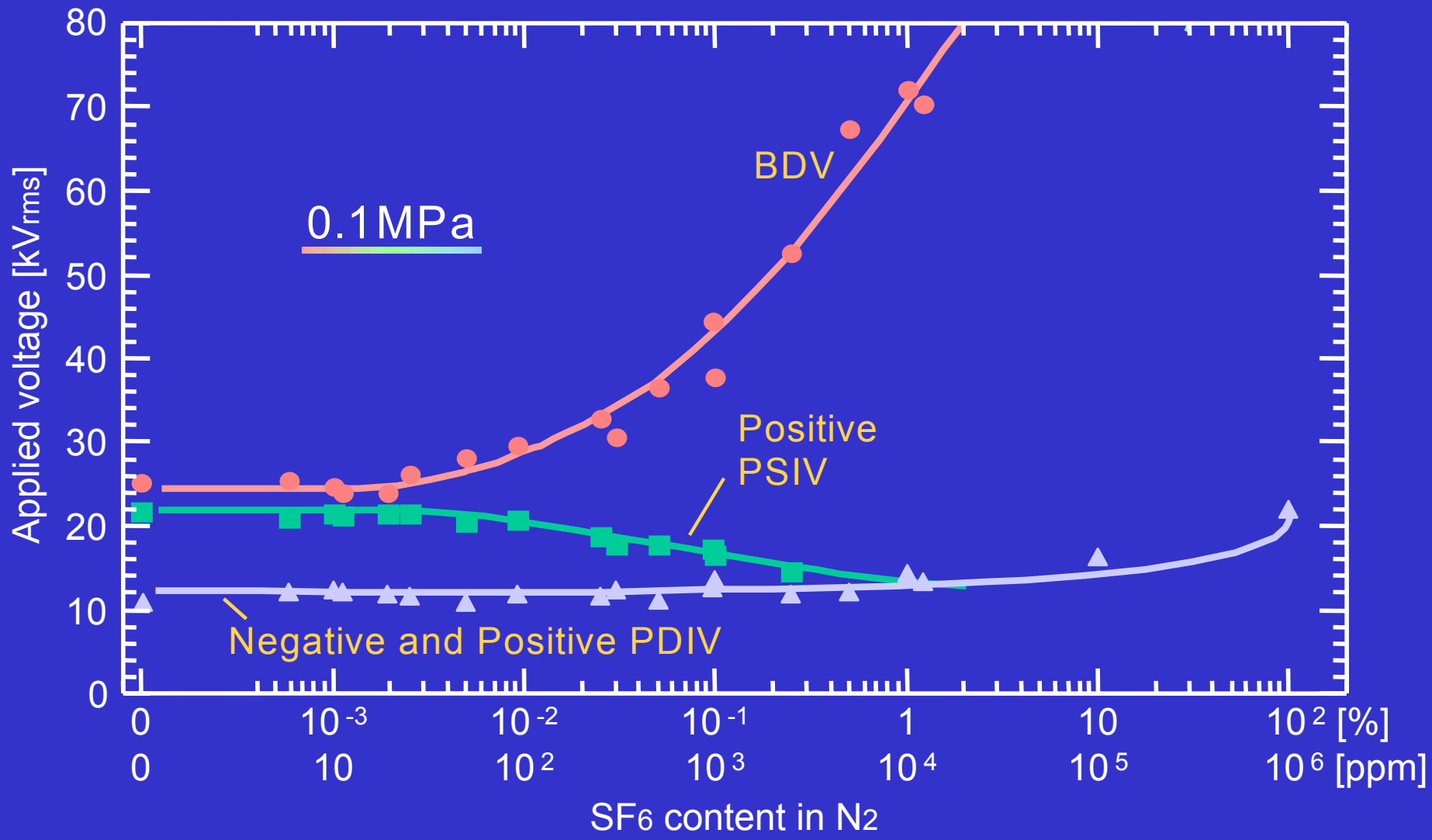
From the view points to reduce SF_6 gas consumption in electric power apparatus, it is very important to clarify the electrical insulation performance of SF_6/N_2 gas mixture, in particular, the one under an extremely small amount of SF_6 gas in N_2.

Firstly, an experiment for the partial discharge characteristics under non-uniform electrode configuration was conducted and it was elucidated that the partial discharge inception voltages were kept constant but the breakdown voltages were changed from about 100ppm of SF_6 content. Secondly, the mechanism was investigated and the generation of return stroke discharge was found playing the important role. Thirdly, the creepage discharge extension characteristics were investigated using the impulse voltage and it was pointed out that the small amount of SF_6 in N_2 strongly affected the discharge extension length, that is, the creepage insulation performance.

In addition, besides with the SF_6/N_2 mixture, the gas mixtures of O_2/N_2 and CO_2/N_2 were also investigated and the partial discharge characteristics were compared with the one in SF_6/N_2 mixture.

Finally, using the obtained data for SF_6/N_2 mixture, the reduction rate of SF_6 gas amount for the electrical insulation design of gas insulated switchgear (GIS) was discussed under the different conditions taking the rated current and the testing voltages for the apparatus into account.

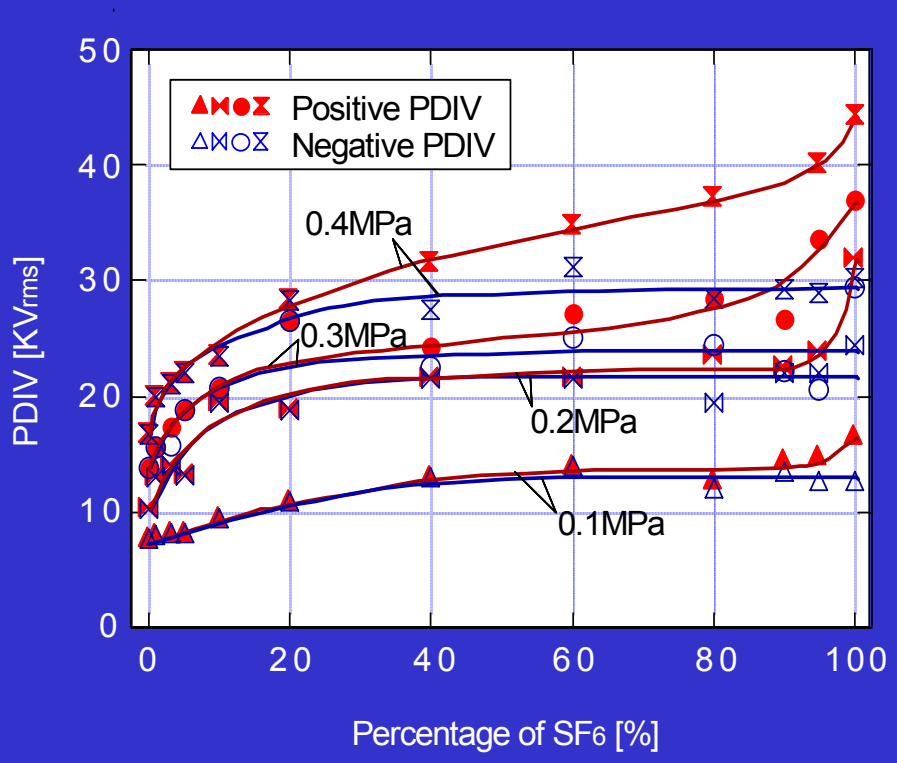
PDIV, PSIV and BDV characteristics

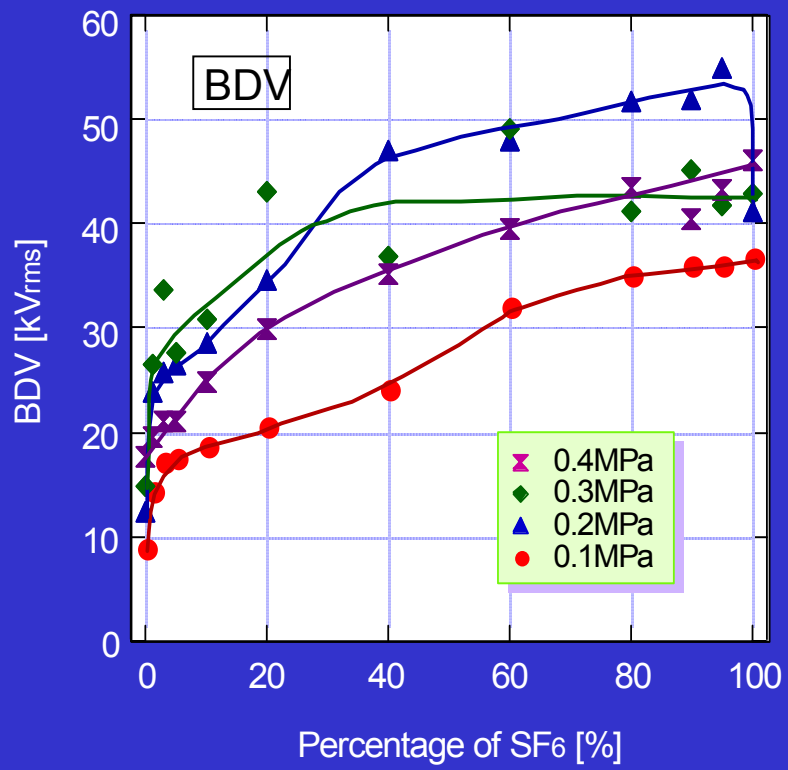


PDIV and BDV characteristics as a function of mixture rate of SF_6.

(r=0.5mm, g=10mm)

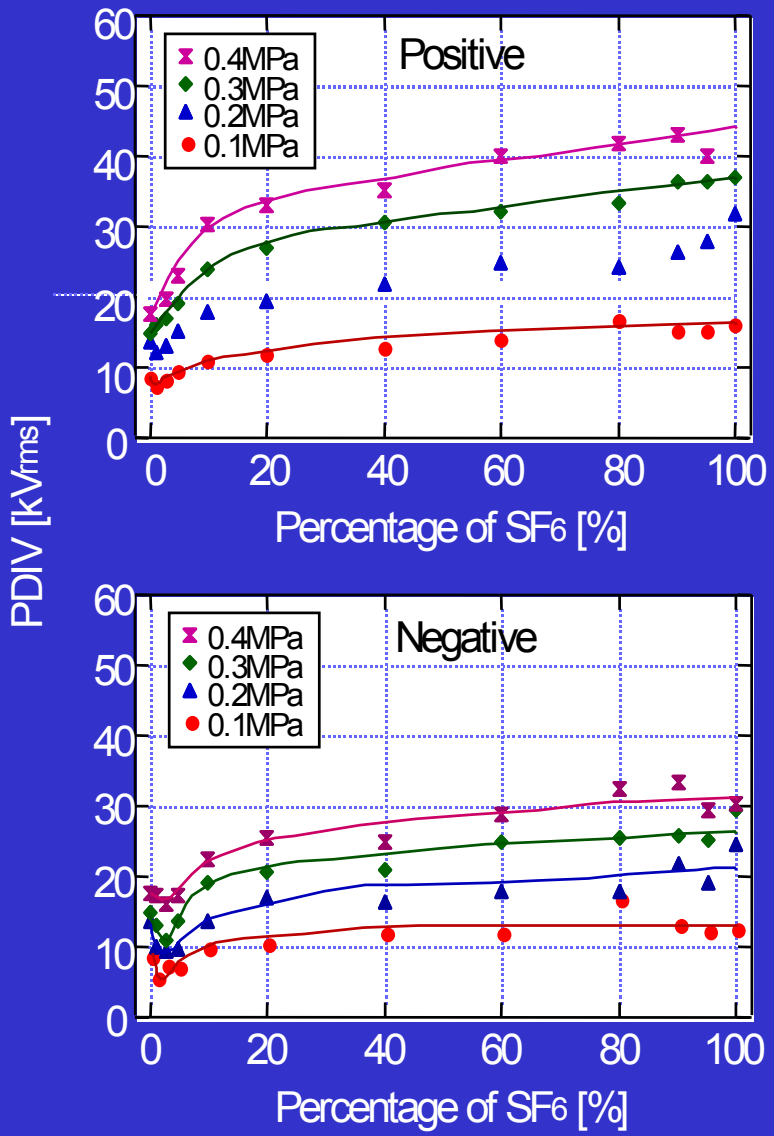
SF_6/N_2 gas

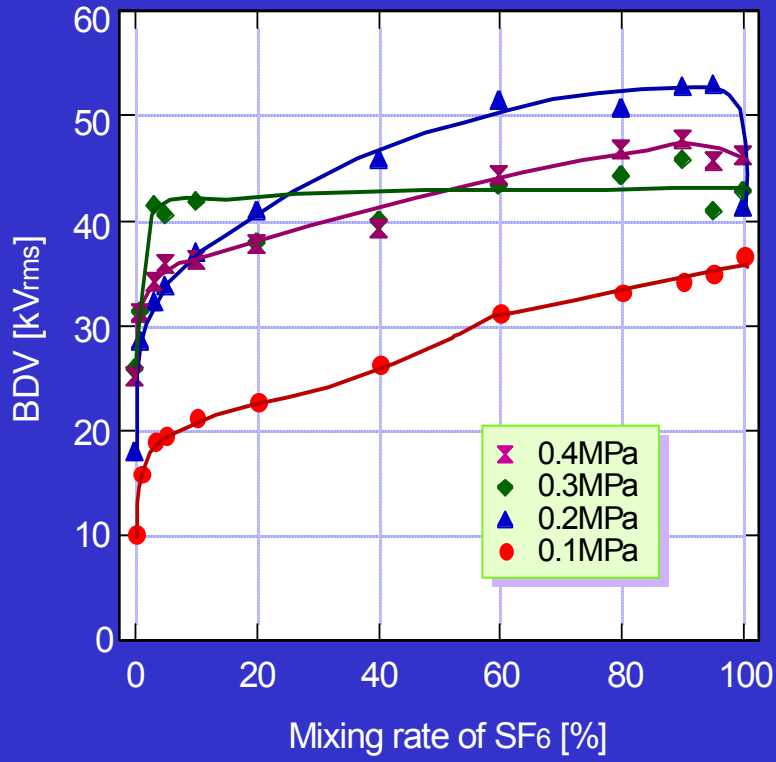




PDIV and BDV characteristics as a function of mixture rate of SF_6.

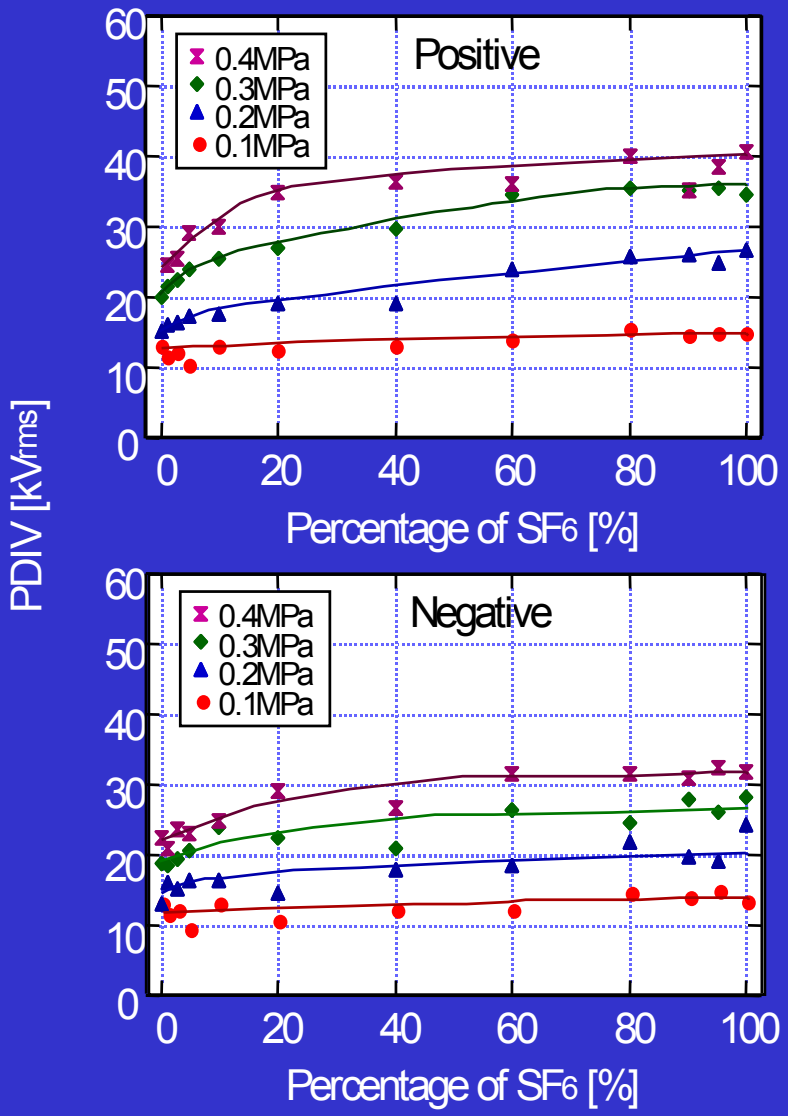
(r=0.5mm, g=10mm, in SF_6/CO_2 gas)

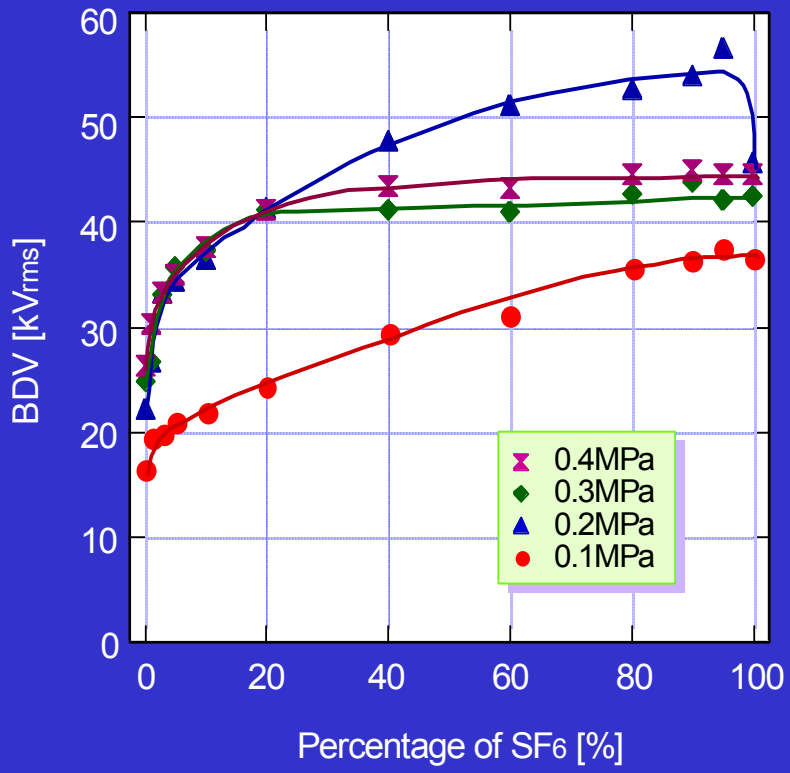




PDIV and BDV characteristics as a function of mixture rate of SF_6.

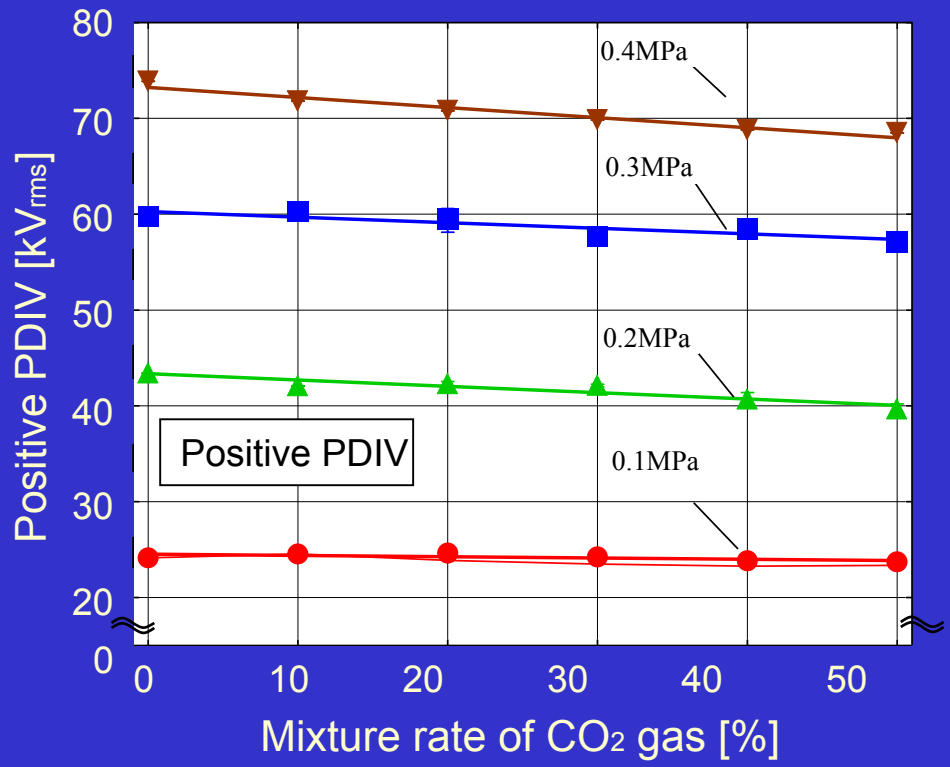
(r=0.5mm, g=10mm, in SF_6/CF_4 gas)

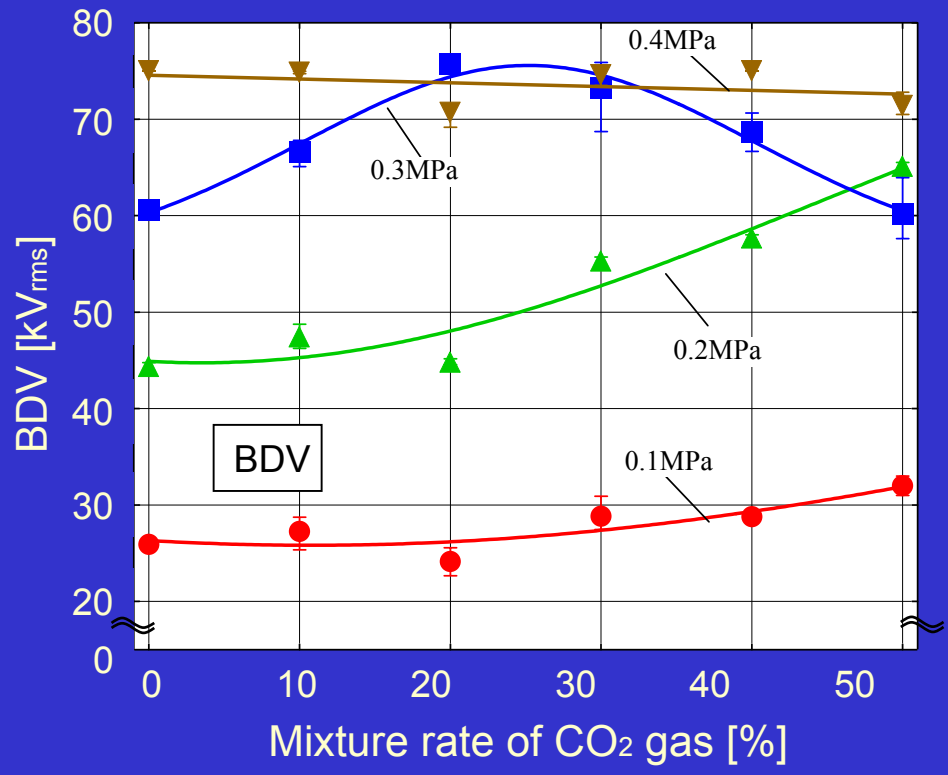




PDIV and BDV characteristics as a function of mixture rate of O_2. (r=2.5mm, g=50mm)

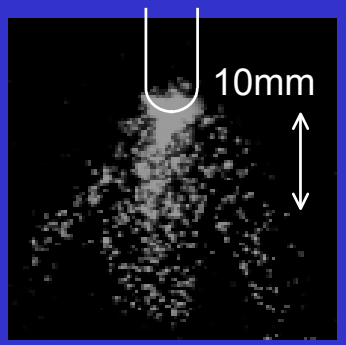
N_2/O_2 gas

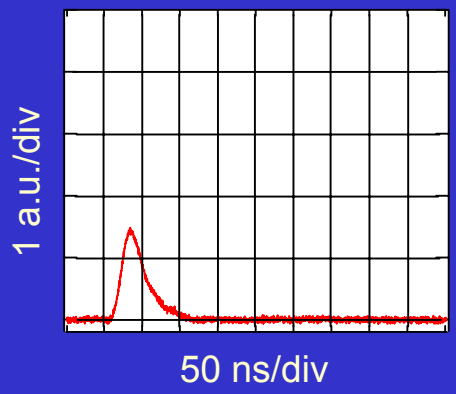




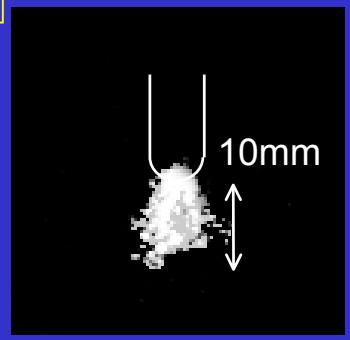
PD light emission image and light intensity pulse waveform (r=2.5mm, g=50mm, θ= 85□95°)

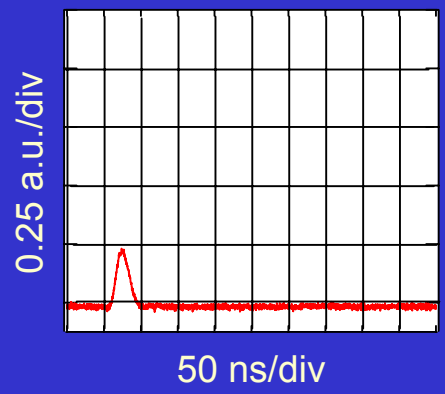
O_2 50%



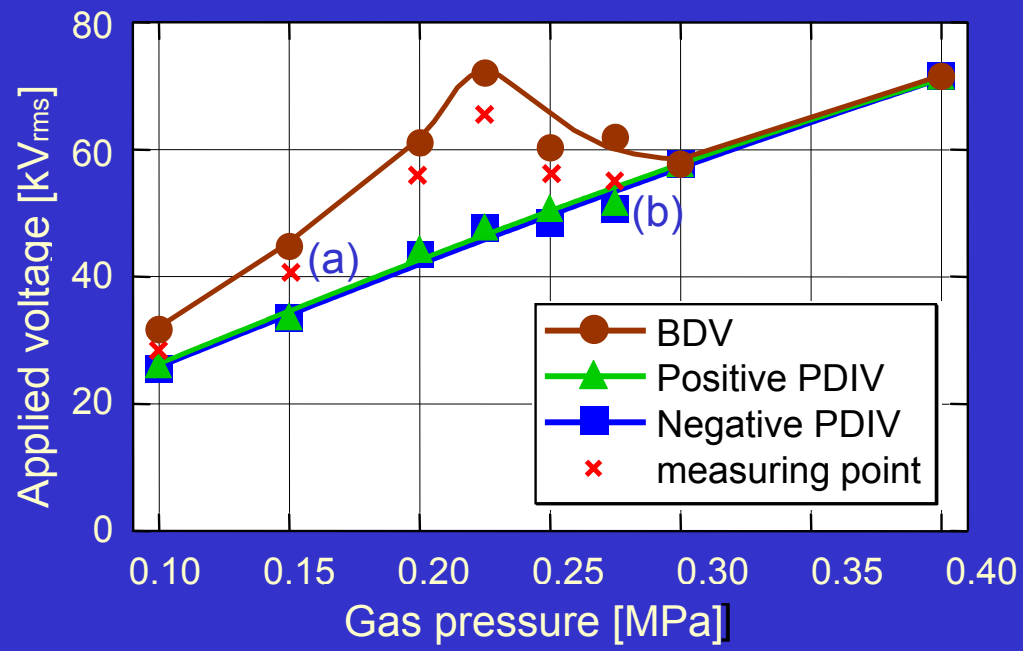


(a) 0.15MPa

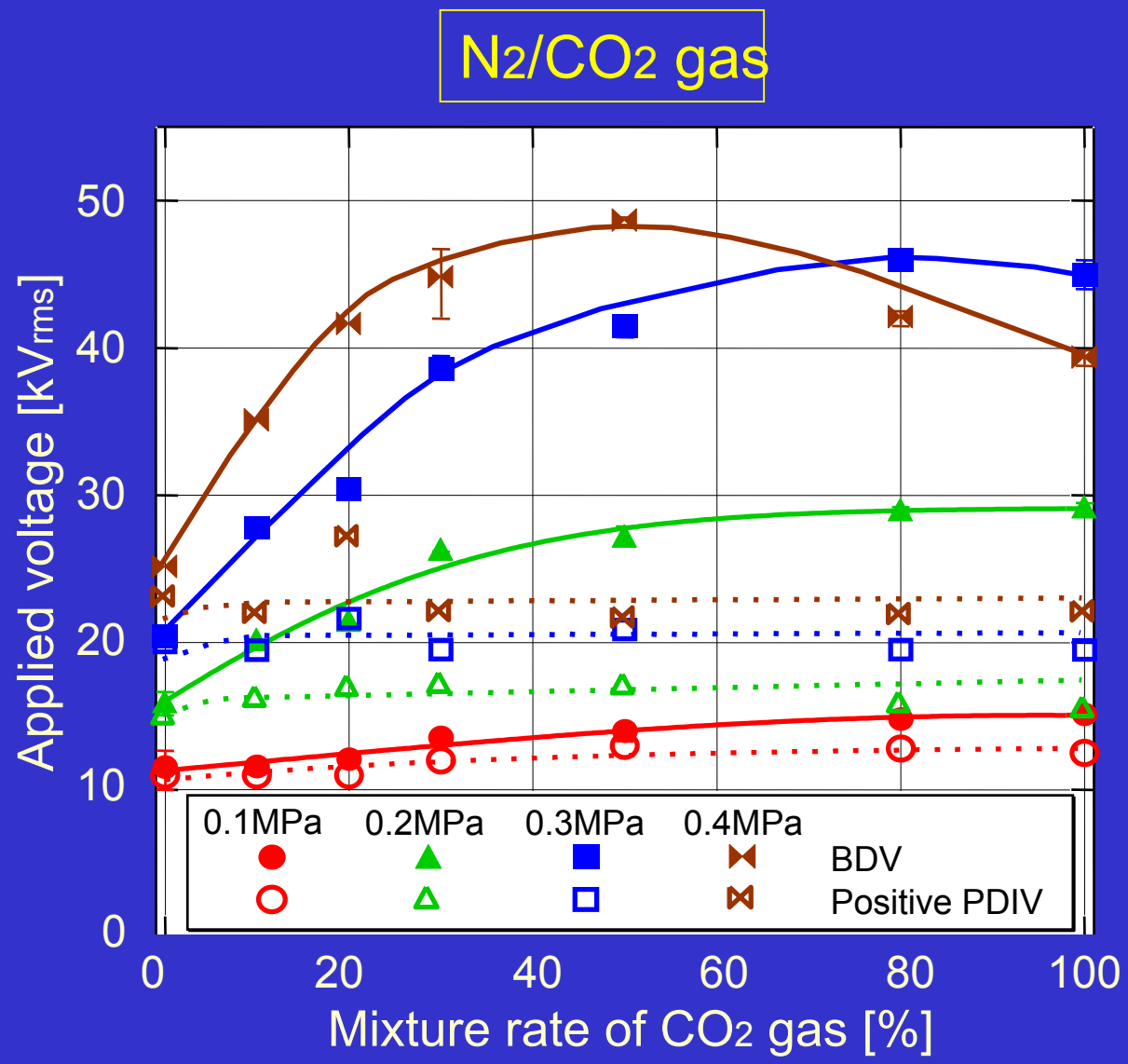




(b) 0.275MPa

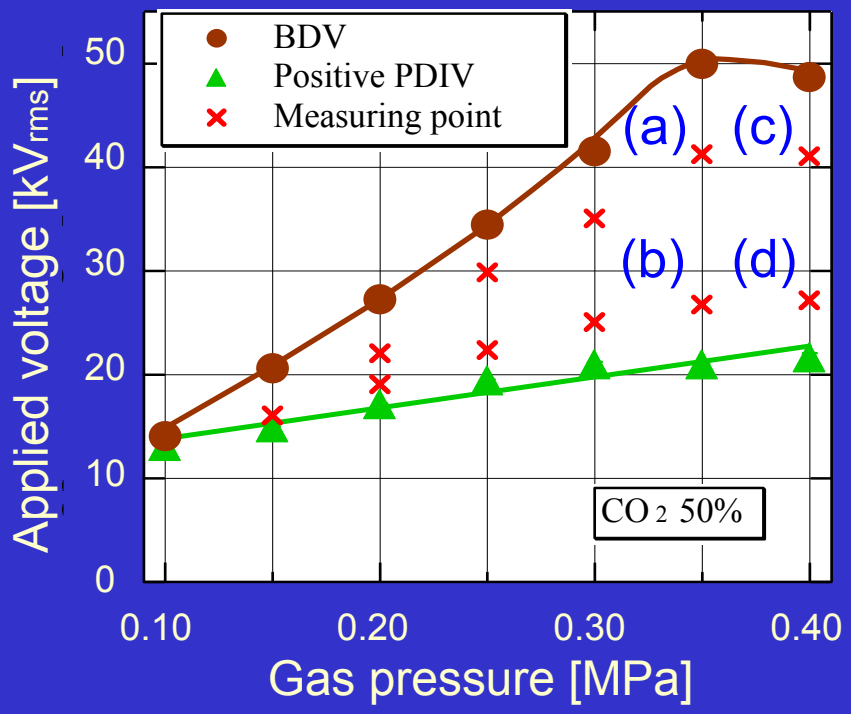


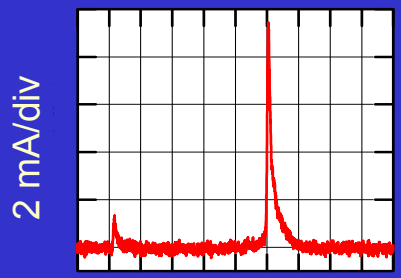
Positive PDIV and BDV characteristics as a function of mixture rate of CO_2 gas. (r=0.5mm, g=20mm)



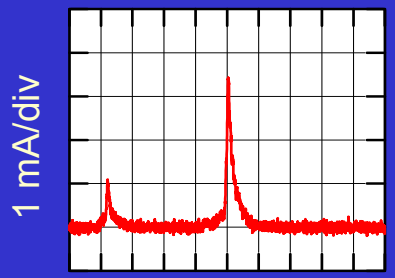
PD current pulses at higher gas pressures. (r=0.5mm, g=20mm)

CO_2 50%

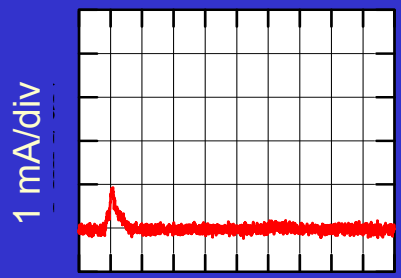




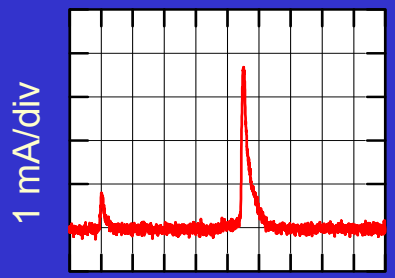
(a) P=0.35MPa
Va=41.2kVrms



(c) P=0.4MPa
Va=41.0kVrms

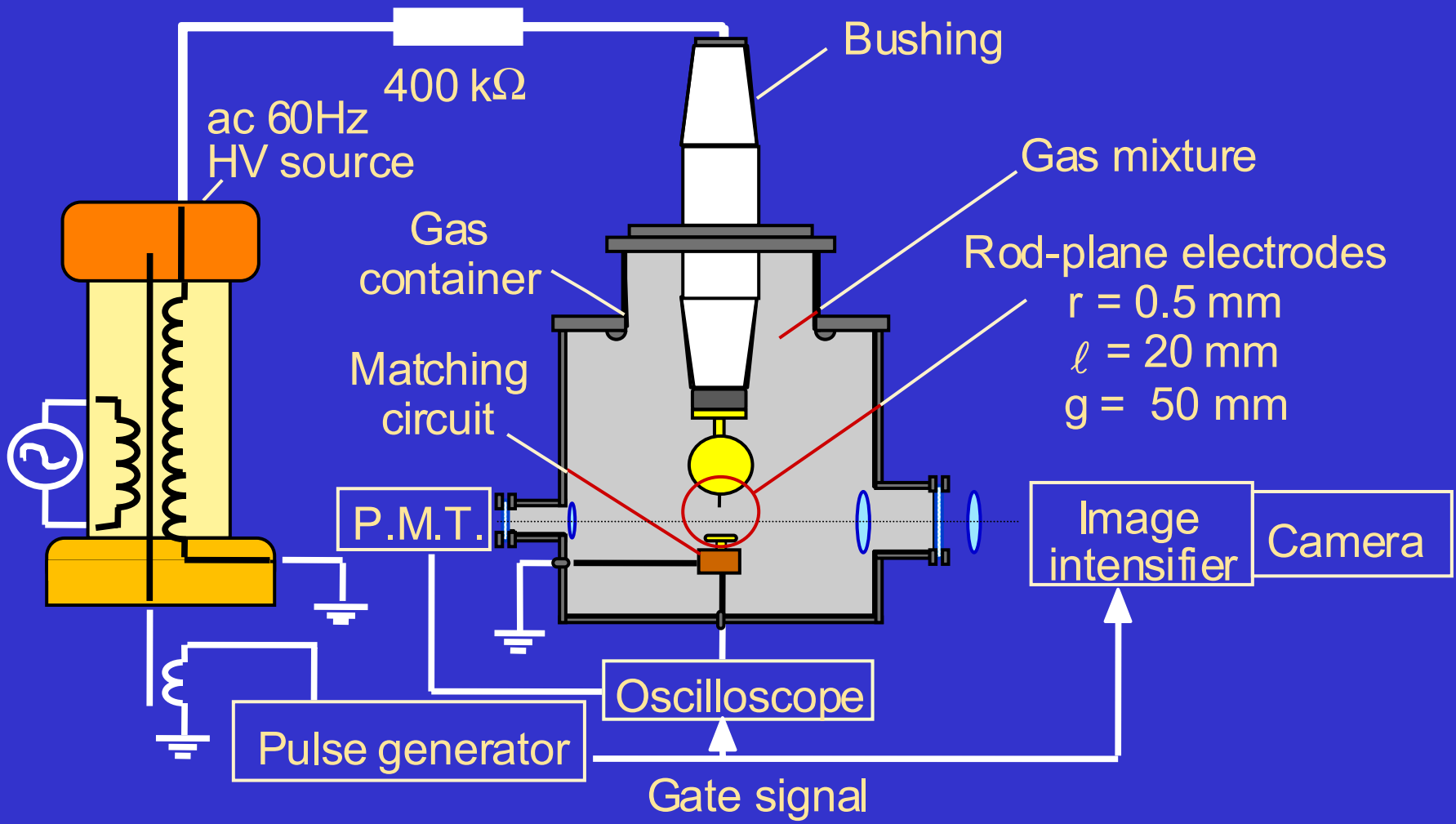


(b) P=0.35MPa
Va=26.7kVrms

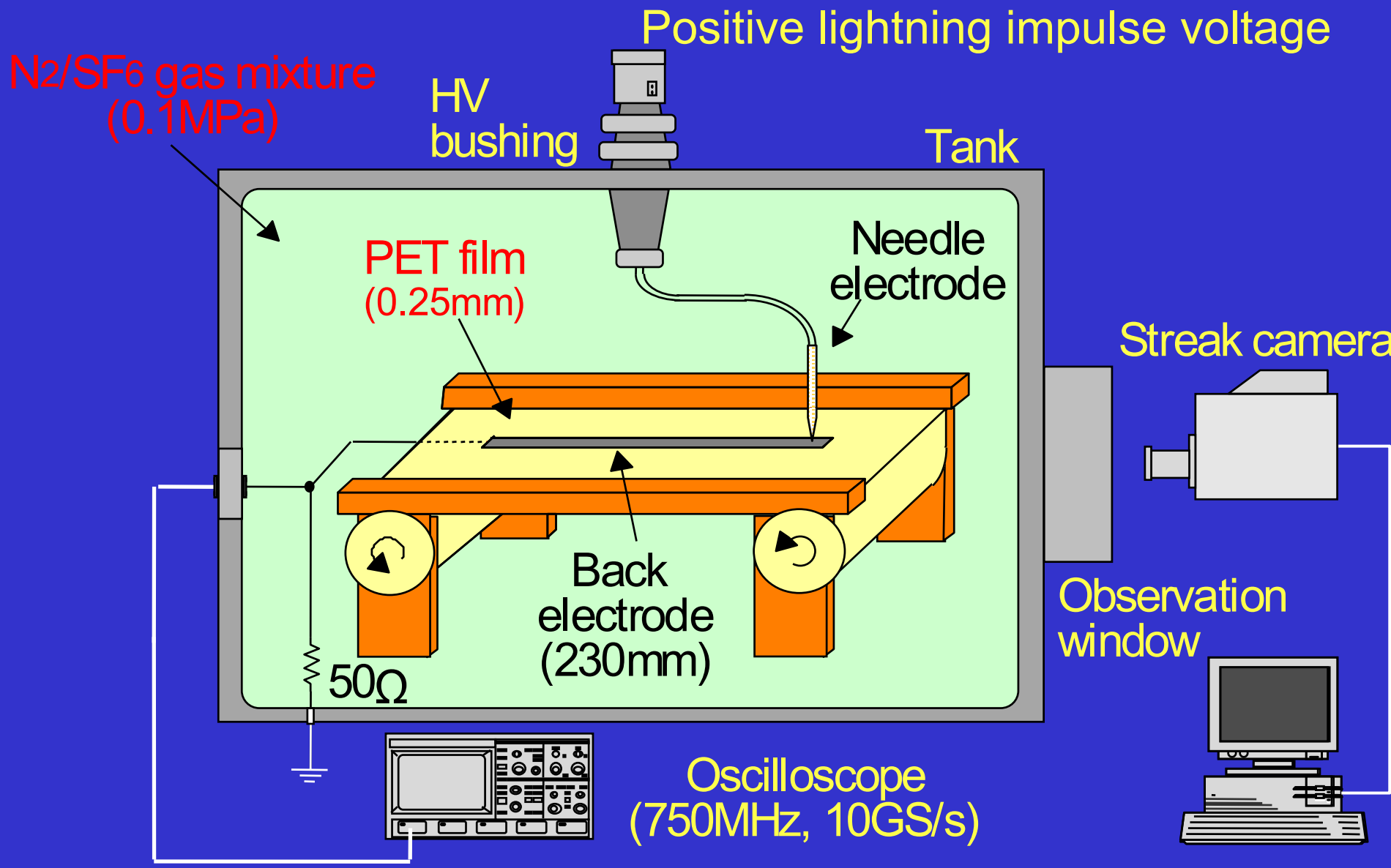


(d) P=0.4MPa
Va=27.1kVrms

Experimental Setup for Partial Discharge Measurement

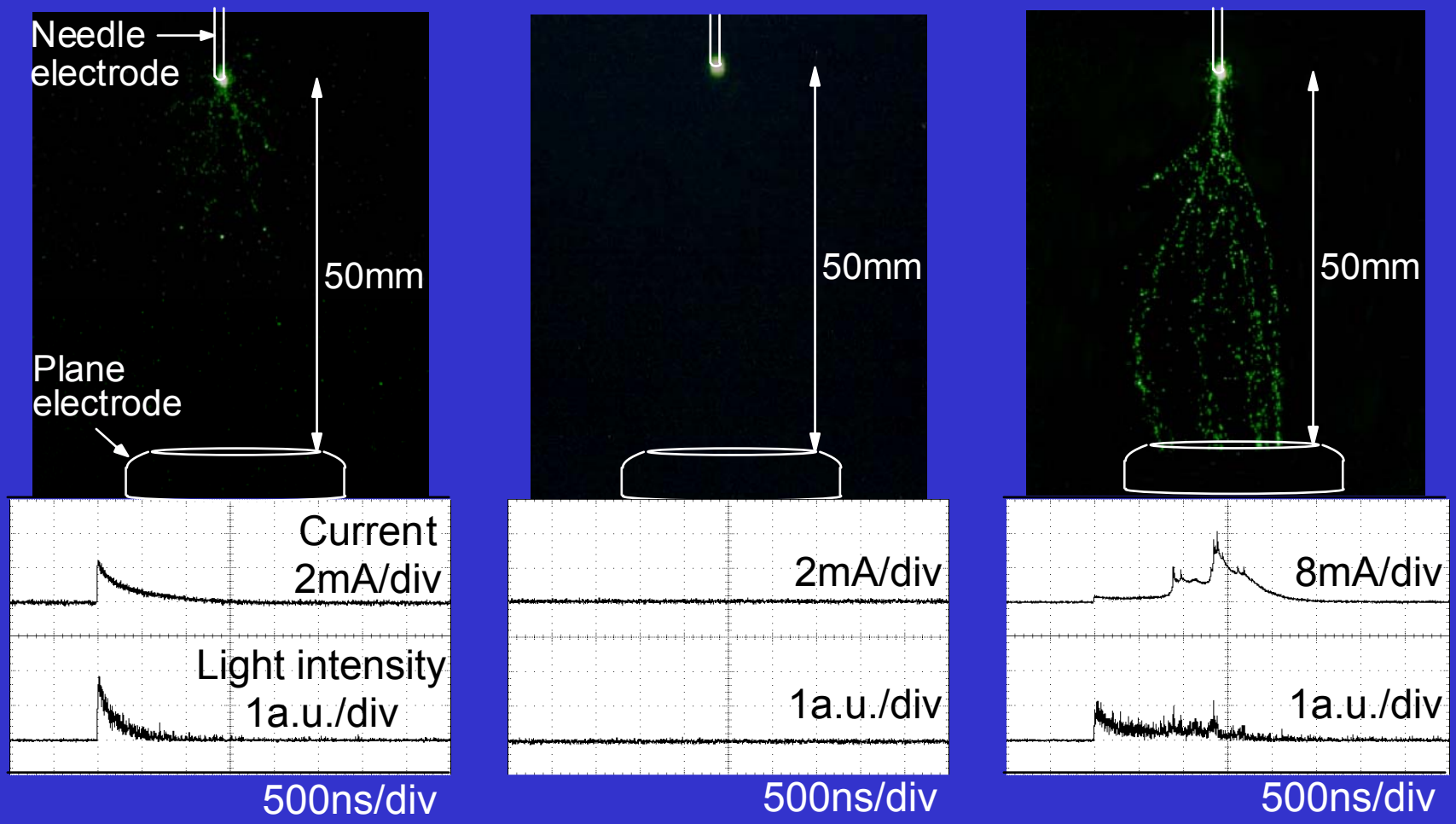


Electrode Configuration for Creepage Discharge



Voltage dependence of PD characteristics in 10ppm SF_6 in N_2

(k = 10ppm, θ = 90˚, P = 0.1MPa)



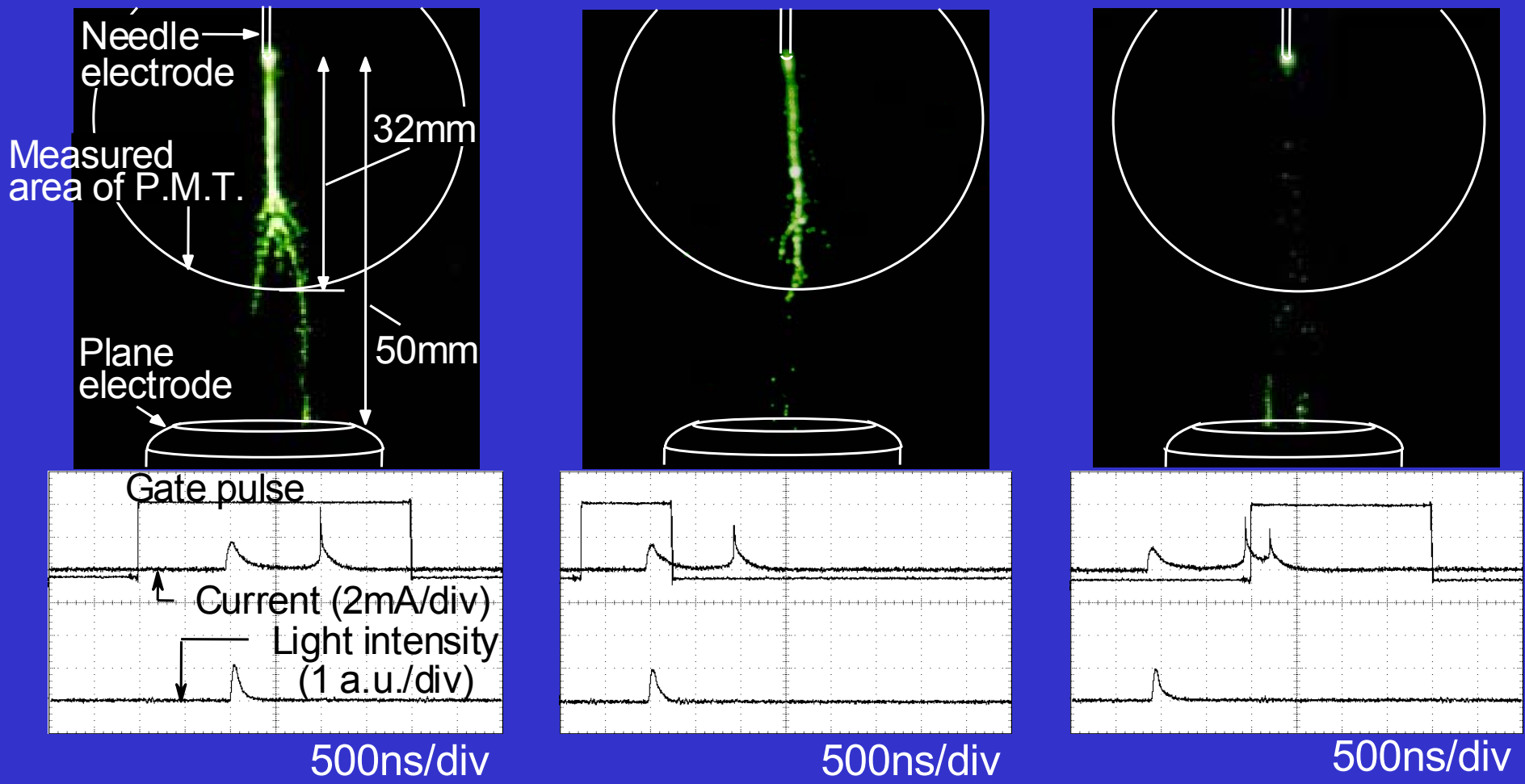
(a) V_a = 13.4 kV_{rms} (= positive PDIV)

(b) PDIV □ $f$$V_a$ □ fPSIV

(c) V_a = 22 kV_{rms} (= positive SIV)

Selective measurement of primary and subsequent current pulses in SF_6/N_2 mixture

(k = 57ppm, θ = 90˚, V_a = 22 kV_{rms}, P = 0.1MPa)

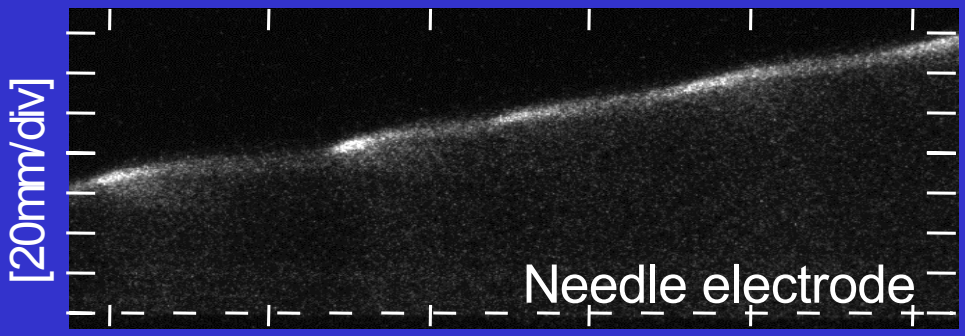


(a) Primary and secondary pulse

(b) Primary pulse

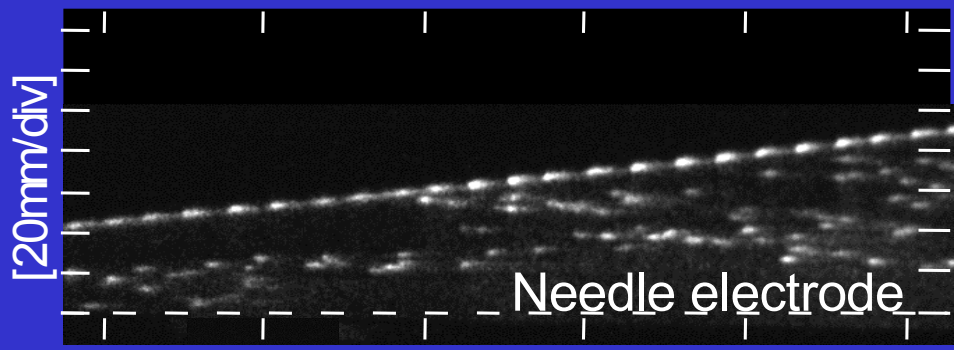
(c) Secondary pulse

Streak image of creepage discharge in N_2/SF_6 mixture



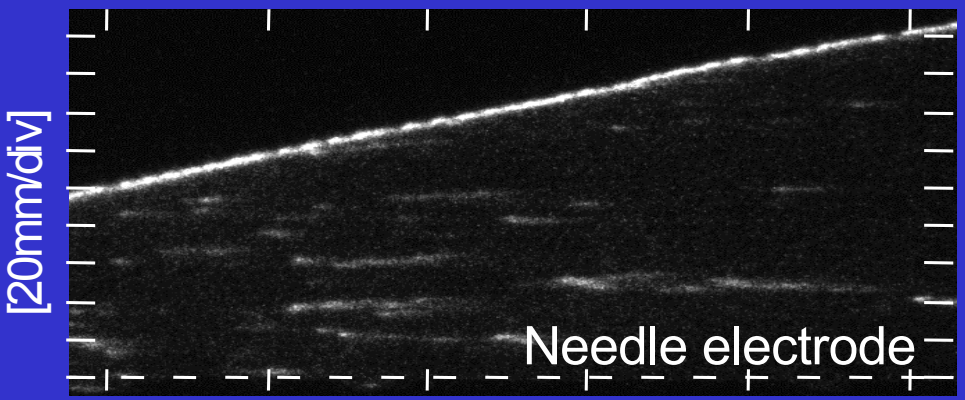
Time [100ns/div]

N_2 100% (Vimp=+26.6kV)



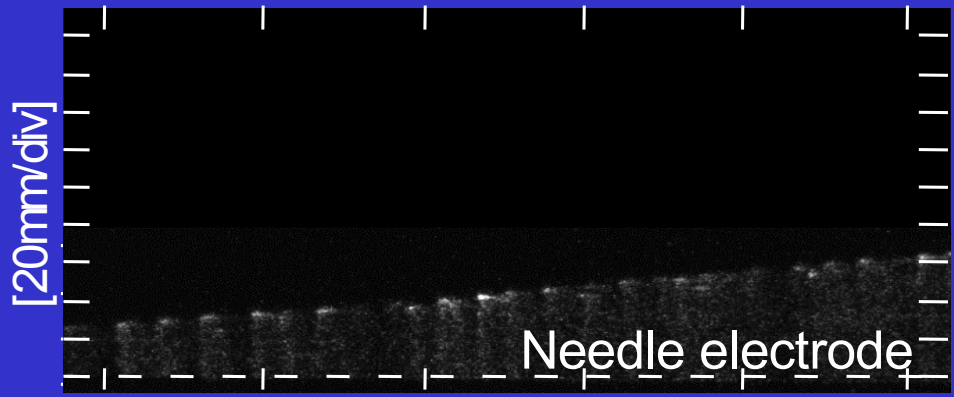
Time [100ns/div]

N_2 50%/ SF_6 50% (Vimp=+26.1kV)



Time [100ns/div]

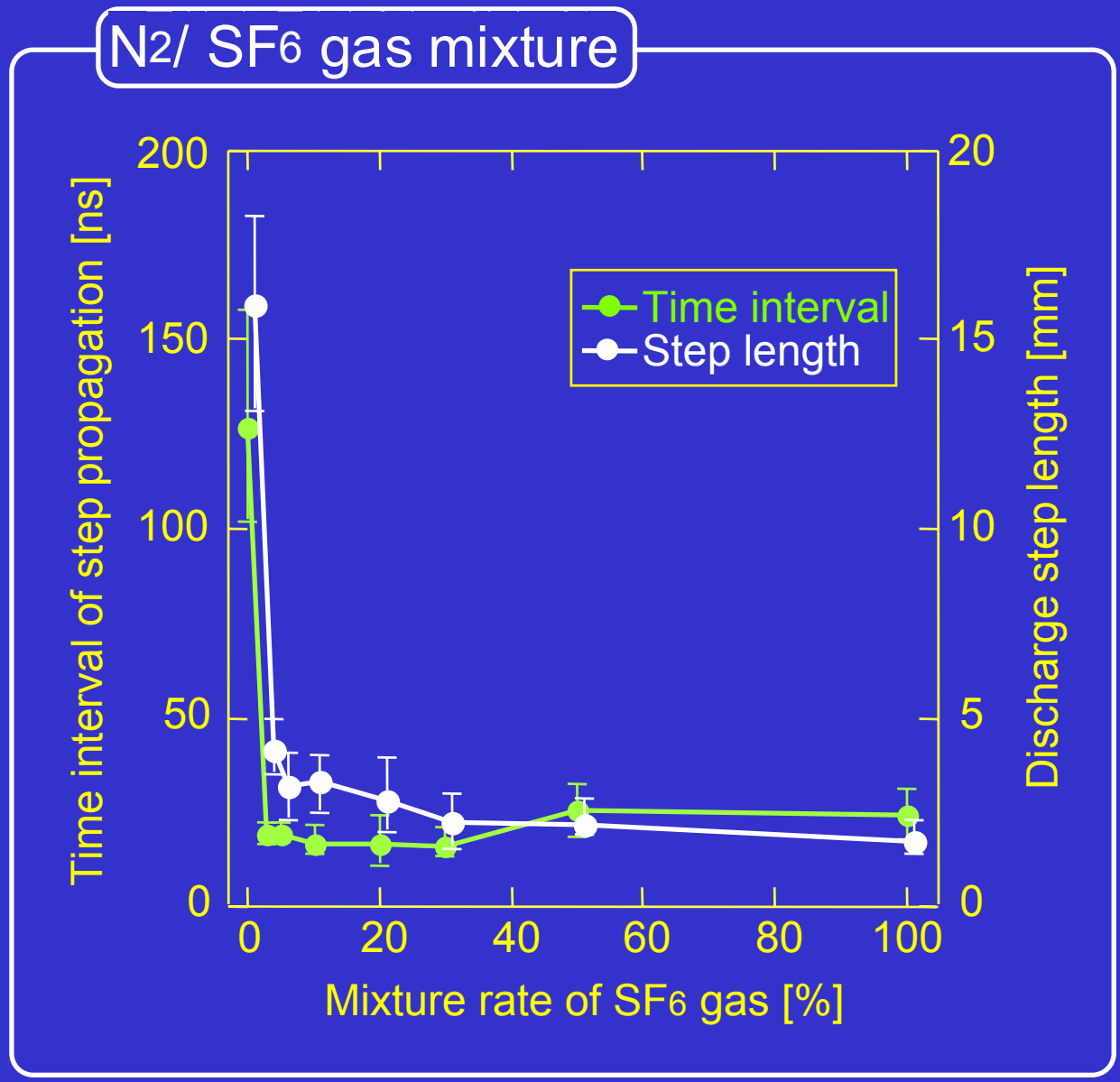
N_2 80%/ SF_6 20% (Vimp=+26.8kV)



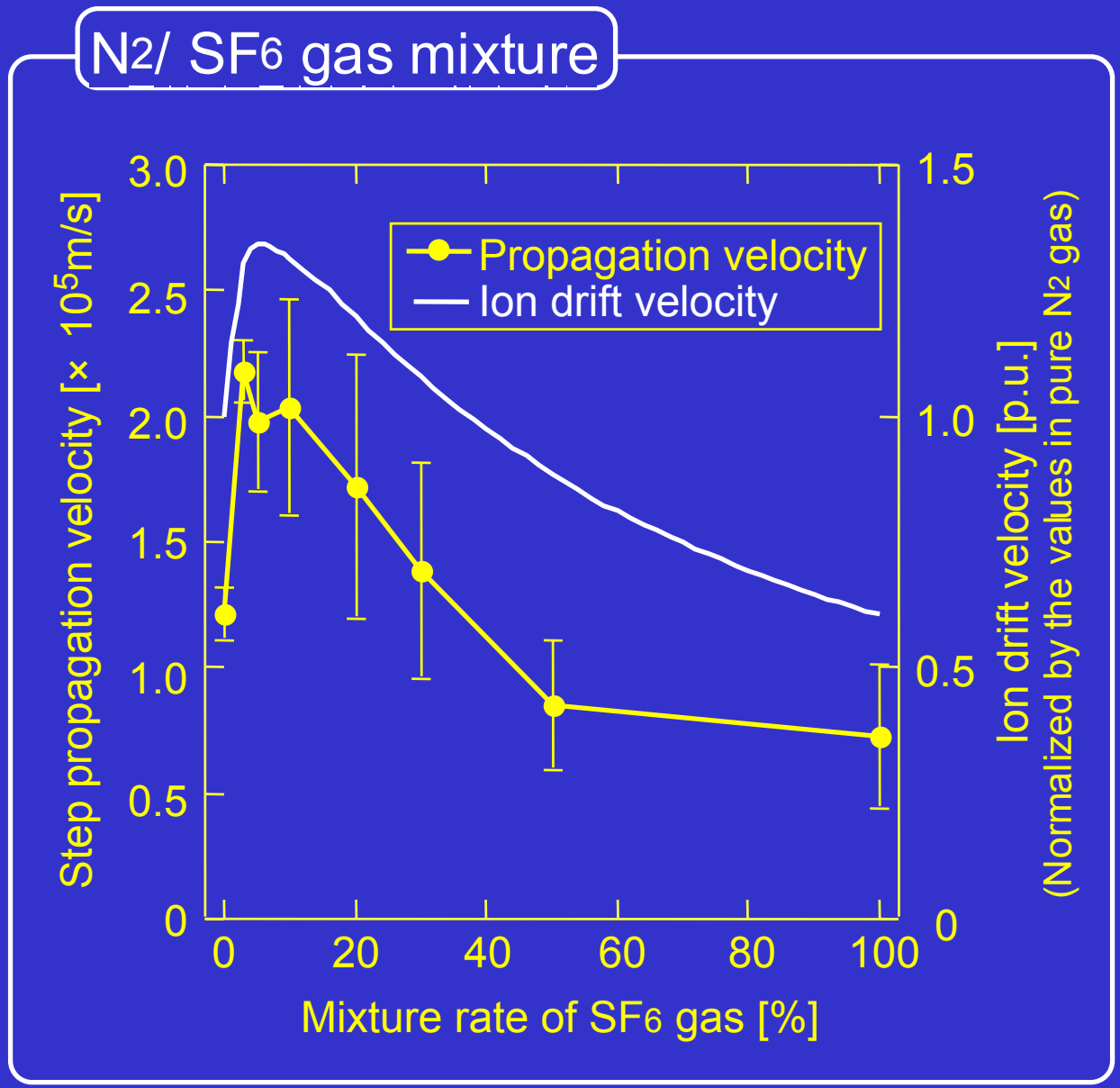
Time [100ns/div]

SF_6 100% (Vimp=+26.1kV)

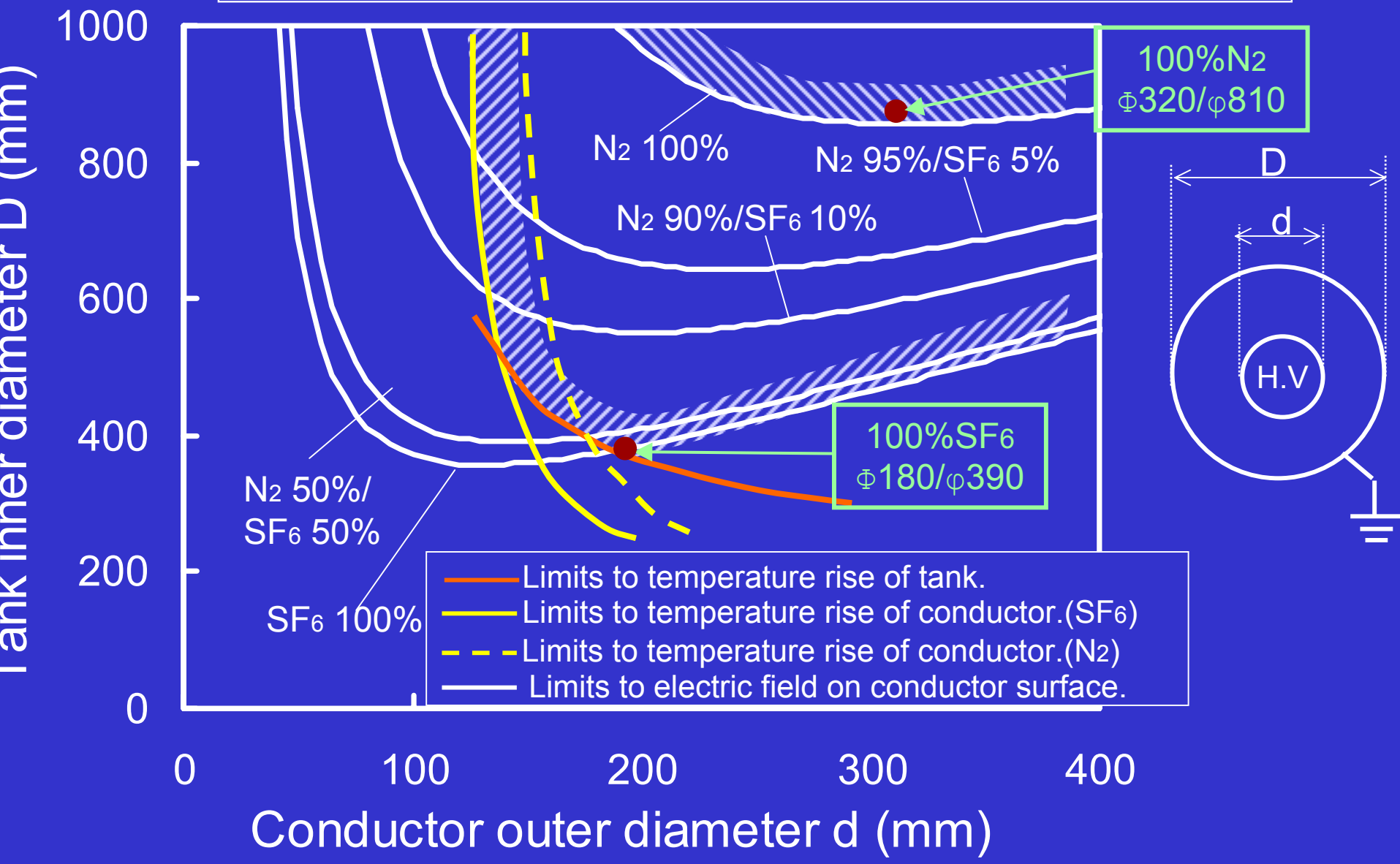
Time interval of step propagation and discharge step length



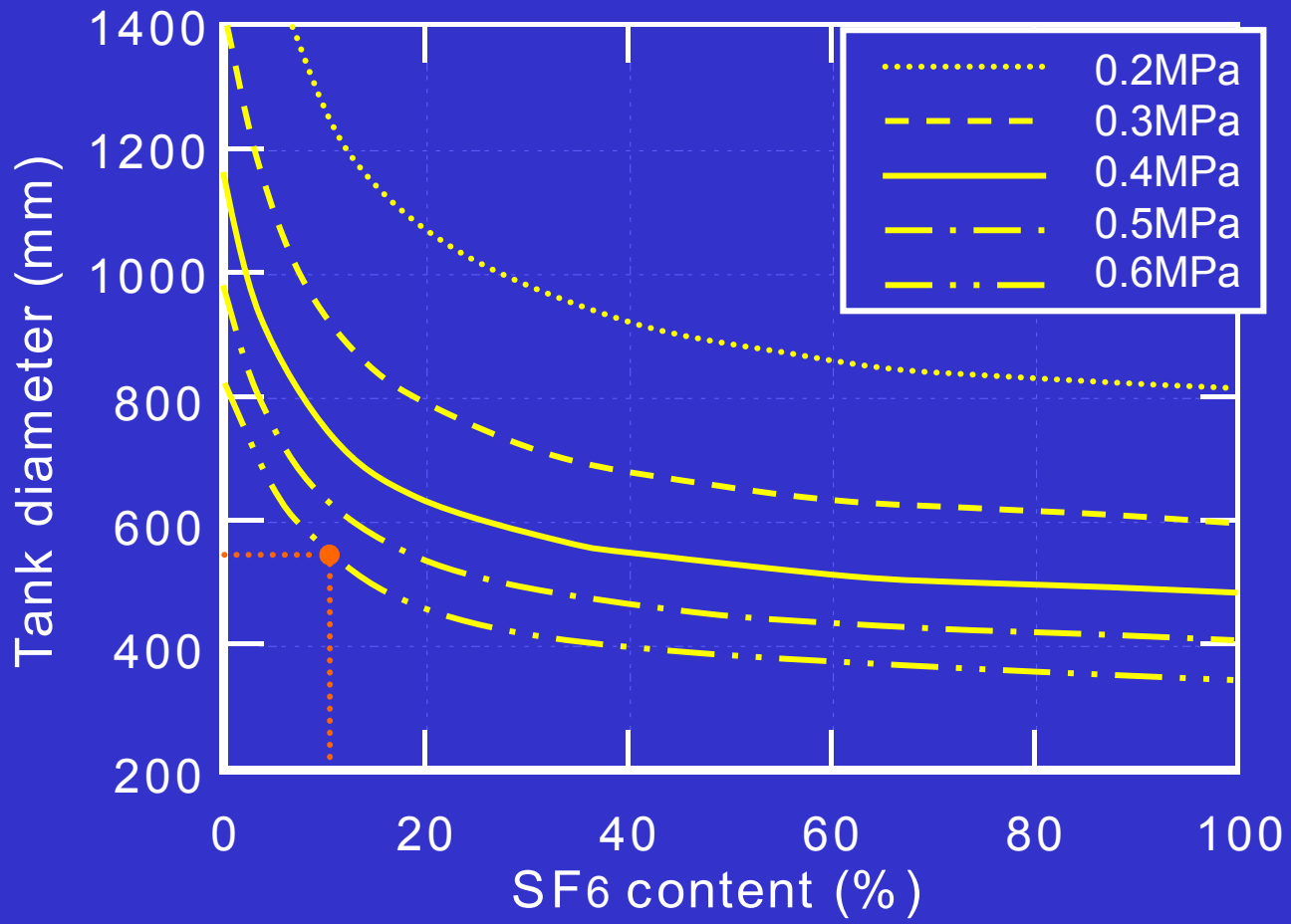
Step propagation velocity and ion drift velocity



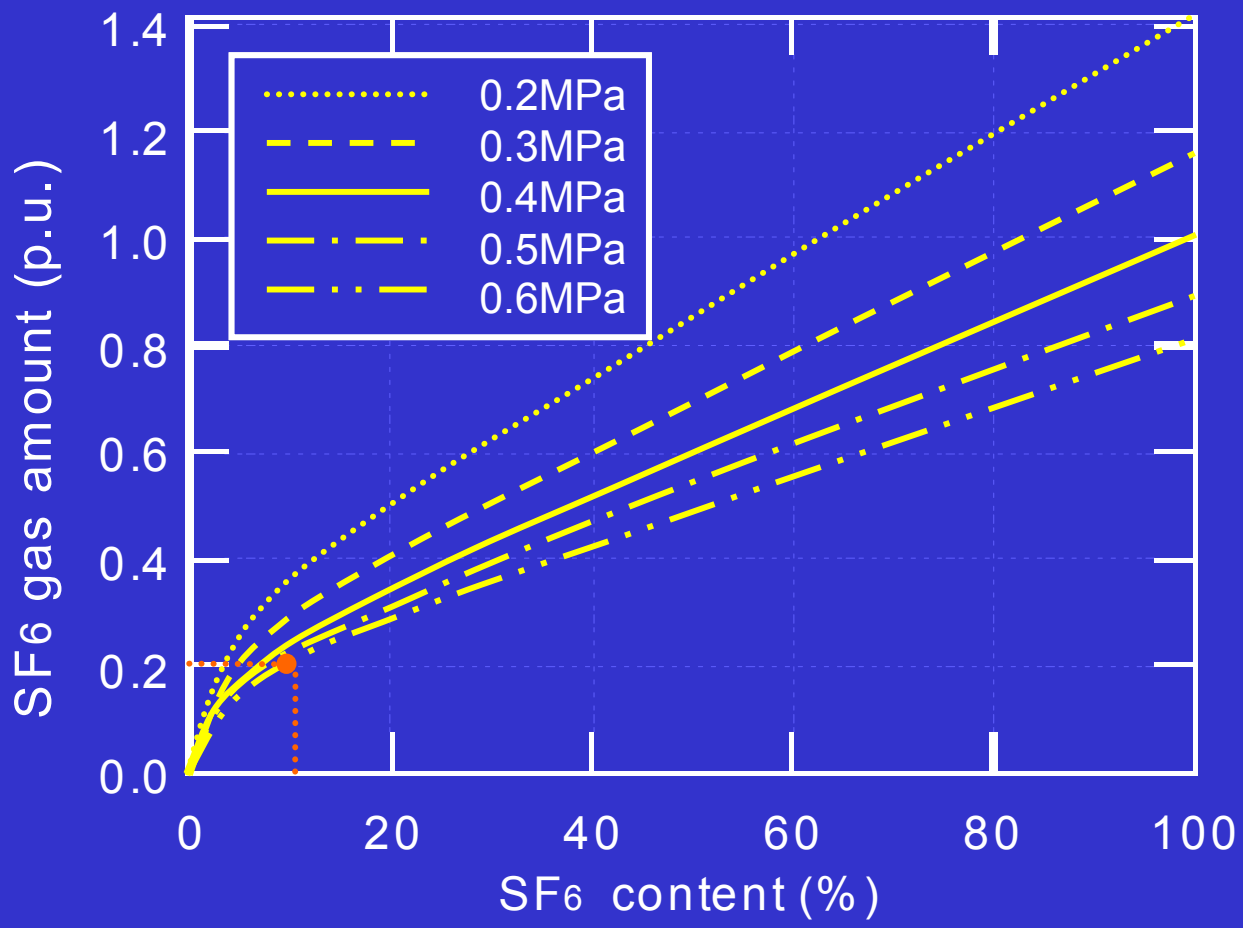
Determination of conductor and tank diameters of 275kV GIS for reduced SF_6 content (P=0.6MPa,6000A)



Minimum tank diameter for different gas pressures as a function of SF_6 content in N_2 (6000A)

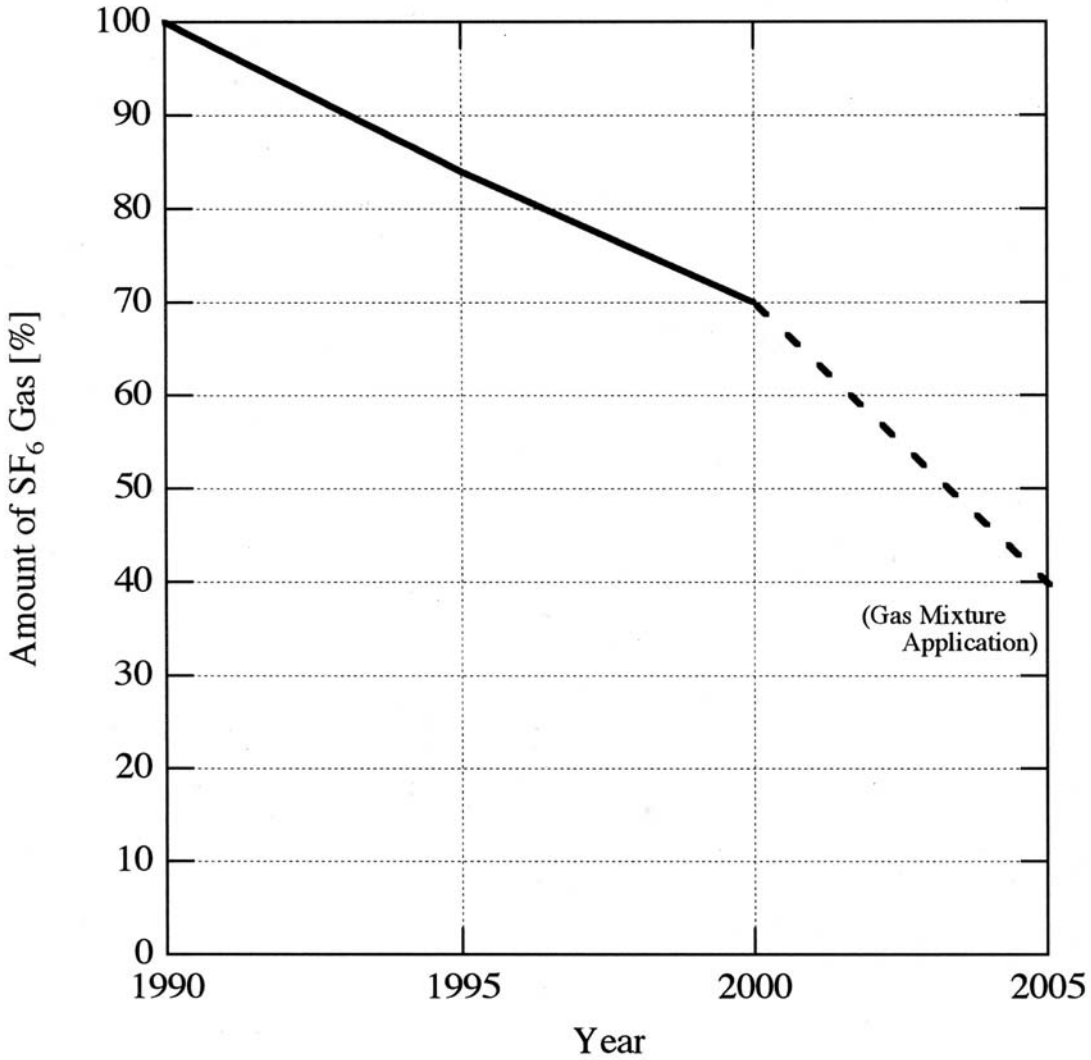


SF_6 gas amount for different gas pressures as a function of SF_6 content in N_2 (6000A)



Gas Insulated Power Transformers (300MVA Base)

Reduction of SF_6 Gas Amount



C-GIS (22/33kV)

Reduction of SF_6 Gas Amount