50X1-HUM

Title: HIGH-VOLTAGE CONDENSERS WITH COMPRESSED-GAS INSULATION by

B. M. Gokhberg, H. M. Reynov and M. P. Glikina (USSR)

Source: Zhurnal Tekhnicheskoy Fiziki, Vol XII, No 1, Russian monthly periodical, p 8-13, 1942

CONFIDENTIAL

CONFIDENTIAL

HIGH-VOLTAGE CONDENSERS WITH COMPRESSED-GAS INSULATION

B. M. Gokhberg,
H. M. Reynov and
M. P. Glikina,
Leningrad Phys-Tech Inst,
Acad of Sci USSR (1941)

This article describes the construction of a high-voltage condenser for high frequencies which is filled with elegas under pressure. Condensers with capacitances of 300, 600, 1200, 2400 and 4000 $\mu\mu$f were tested at 40 kv for frequences up to 1.2×10^6 with 100% modulation.

1. INTRODUCTION

At present compressed-gas insulation has acquired very great significance. Because of the absence of dielectric losses, gaseous agents are the best insulation in high-frequency technology. In spite of its small dielectric losses, however, gaseous insulation could not at first compete with solid and liquid dielectrics because of its relatively small resistance to rupture at atmospheric pressure, which possess a greater resistance to rupture.

The resistance of gas ~~A gas' resistance~~ to rupture can be raised by ~~one's~~ increasing the pressure. In a uniform electrical field the breakdown voltage rises linearly with pressure within the limits of several tens of atmospheres. For a non-uniform field the breakdown voltage rises more slowly, and the higher the pressure the less the increase in breakdown voltage for each subsequent increase in pressure.

In radio engineering compressed nitrogen serves to solve the problem of gaseous insulation in condensers. In the US ~~America~~ condensers with nitrogen are beginning to be used and are being widely advertised; the condensers possess a capacitance of 1500-2000 $\mu\mu$f, calculated for operation at 30,000-40,000 volts, and are filled with nitrogen up to 40 atmospheres.

CONFIDENTIAL

Declassified in Part - Sanitized Copy Approved for Release 2012/05/25 : CIA-RDP82-00039R000100100022-6

Our laboratory in the Leningrad Physico-Technical Institute investigated the breakdown resistance of different gases. Several dozen gases were studied, especially gases with electrical resistance higher than that of air. We were particularly tempted by the idea of using such high-resistance gases as gaseous insulation and particularly by the idea of applying them to high-voltage no-loss condensers.

Many gases cannot be used, in spite of their high electrical resistance, ~~on account~~ because of certain unfavorable chemical or physical properties. The possibility of using gases with high electrical resistance is determined by: 1) chemical inertness, 2) the pressure obtainable without danger of conversion to the liquid state, and 3) weak dissociation during an electrical discharge.

Of the gases which we investigated particular attention was paid to sulfur hexaflouride which, as it appeared to us, possesses exceptionally favorable properties for its use as insulation. Its breakdown resistance is 2.5 times greater than ~~air.~~ that of air.

Sulfur hexaflouride (SF_6) possesses the following properties: At $-62^\circ C$ its vapor pressure over solid sulfur hexaflouride equals 760 mm/Hg; at $-50.8^\circ C$ SF_6 melts, having a saturated vapor pressure of 1710 mm/Hg; the critical temperature of the gas is $54^\circ C$; and at room temperatures the pressure of the saturated vapors approaches several tens of atmospheres. Sulfur hexaflouride is chemically stable, possesses a high temperature of dissociation, and dissociates weakly during an electrical discharge.

We proposed to use sulfur hexaflouride in various high-voltage devices, particularly in condensers.

In order to indicate the particular usefulness of SF_6 for use in the electrical industry and in high-voltage technology, we conditionally called it "elegas".

2. DESCRIPTION OF THE CONDENSER DESIGN

The ~~constant~~ Fixed capacitance condensers which we constructed and investigated consist basically of an iron container sealed hermetically by a lid to which are attached the condenser plates and a high-potential lead (outlet). The general form of the condenser is pictured in Figure 1.

The high-potential lead is manufactured from optical glass and possesses an efficient configuration (namely, a hemisphere) for operation under compression. The lead consists of two hemispheres (A) one functions and withstands the gas pressure inside the condenser, and the other hemisphere serves merely as a support for the lead shaft (B).

Several dozen hemispheres were satisfactorily tested at hydrostatic loads of 10 tons. To prevent damage, air is inserted at normal pressure inside the hemispheres, which is achieved with the aid of vent (C). This vent also serves to control the compression of the working hemisphere. Chloroprene packing (E) is laid between the hemispheres and the lid (D); there are similar gaskets between the high-potential shaft and the hemispheres.

First the outlet lead is assembled separately on the lid of the container and the whole system is tightened by nuts on the high-potential shaft. Then, when the condenser has been assembled, the functioning hemisphere is automatically compressed and sealed by the gas pressure inside the container.

To guard against flash-over along the surface of the insulators and to improve the electric-field distribution along the surface of the external glass insulator, the disk (K) was placed on the high-potential outlet. To guard against marginal effects, the disk has a rim with large radius of curvature.

The condenser consists of a set of aluminum disks, where the low-potential plates are mounted on three rods and fastened to the lid of the container and the high-potential plates are fastened to the lead shaft. The low-potential plates can be moved vertically with the aid of the screw jacks (L), which are a part of their fastening rods — this allows the distance between the high potential and low potential plates to be adjusted comparatively accurately. In order to distribute the electric current uniformly, which is essential for the operation of a condenser at high frequencies (with large currents), all three rods are connected together by the busbar (M), which is connected by a terminal on the lid through a copper lead.

At the bottom of the condenser is a guide insulator (N) to eliminate misalignment between the systems of high and low potential plates (which results from the action of electric forces between them because of inaccurate spacing). The insulator, made of optical glass, is fastened to the ends of the three rods holding the low-potential plates, sufficient clearance being provided to prevent its breaking on heating up due to different coefficients of thermal expansion of glass and metal. The set of condenser plates ends on both top and bottom with high-potential plates. This creates a distributed electrical field in the space between the ~~containers~~ plates, bottom, and lid of the container and protects the insulators in these gaps from surface flash-over. In low-capacity condensers the guide insulator is absent, since the resilient action of a short high-potential shaft is sufficient to keep the plates from becoming misaligned.

The condenser containers are made of seamless tubing with a flange added for fastening the lid. The bottom of the container is carefully welded on both sides. The lid is fastened on with ten bolts. To achieve a seal with the container, the lid has a circular slot 10 mm wide and 5 mm deep filled with chloroprene packing. Into the slot ~~goes~~ the circular end of the container goes.

The containers as well as the lids and high-voltage glass outlet leads were tested at hydrostatic loads up to 40 atmospheres, and even at this no defects were noticed. To fill the condenser with gas, a special shut-off valve was inserted on the container's side. The valve housing is so constructed that a manometer placed in it constantly indicates the pressure inside the condenser. The shank of the valve has a hardened ball on its shut-off end which hermetically seals under pressure the inlet passage. Its good properties were proven by lengthy tests of the valve at high pressures.

In order to reduce heating-up due to high-frequency currents, all iron members were electroplated with copper.

Figure 2 shows a photograph of the 2400-$\mu\mu$f condenser, and Figure 3 shows the same condenser in its assembled form and the 1200-$\mu\mu$f condenser.

3. RESULTS OF TESTS

First we tested two condensers for the following: 1) sealing properties, 2) the influence of the distributi~~on~~ng ~~apparatus~~ device on flash-over and breakdown of the condenser's insultors ~~the condenser's resistance to rupture and~~ 3) the behavior of the high-potential leads under pressure and under heating by high-frequency currents.

In addition, different packing materials were tested for their behavior in condensers. After testing the two condenser specimens at direct current in the laboratory and at high frequencies in the factory, we had five condensers of different capacitances made.

Tests, with nitrogen and elegas, of these five condensers were conducted for direct current and high-frequency currents at different pressures and frequencies.

The condensers were filled, from ordinary cylinders, with nitrogen passed through calcium chloride (for partial elimination of moisture from the gas and porous glass filters. At a pressure of 1-2 atmospheres the condensers were charged at small voltages to destroy and dust remaining on the plates. To fill the condensers with elegas, the low-pressure elegas possessed by the laboratory was brought to a higher pressure by a thermo-compressor and then introduced into the condenser.

Figure 4 shows the dependence of breakdown voltage (for direct current) on pressure for a condenser filled with nitrogen and elegas. Spark-over in elegas at a pressure of only 3 kg/cm^2 occurred at 50 kv, while spark-over in nitrogen at the same voltage occurred when the pressure was 9 kg/cm^2.

High-frequency tests were conducted for wavelengths of 1300, 700, and 250 meters. Figure 5 shows the comparative rupture curves of condensers filled with elegas and nitrogen for 700 meters. As is evident from the curves, elegas is clearly superior to nitrogen for direct current and alternating current. It ought to be noted that these curves do not accurately describe breakdown-voltage versus pressure, since the condensers repeatedly broke down during the measurements, which resulted in some damage to the plates and thus to lower values of breakdown-voltages. In addition we should emphasize here that condensers with gaseous insulation can repeatedly break down without getting out of order unlike condensers with solid or liquid dielectrics in which rupture leads to irreparable damage to the condenser.

The high-frequency tests were conducted at 100% modulation, ~~be-sides,~~ and the reactive power reached 2000 kva in the 1200 $\mu\mu$f condenser. At this power the condensers heated up only to about 70°C without any forced cooling. The glass outlet leads heated up the same amount. Because the glass was in a relatively low electrical field, losses in the glass were not great, although the loss angle for the given type of glass is 9' (minutes). At present this glass can be replaced with others having smaller loss angles.

4. SUMMARY OF RESULTS

1. ~~The construction of~~ special high-voltage leads designed to withstand ~~to stand high-~~ pressure were developed and tested ~~which~~ using glass hemispheres operating under compression.

Declassified in Part - Sanitized Copy Approved for Release 2012/05/25 : CIA-RDP82-00039R000100100022-6

With a simple apparatus that ~~guaranteed~~ assured the distribution of the electrical field, we tested insulators ~~that permitted~~ at operating voltages up to 40 kv, peak value, and frequencies up to 1.2 Mc.

2. We first built and tested an experimental model, and then five ~~constant~~ fixed capacitance condensers of 300, 600, 1200, 2400, and 4000 $\mu\mu$f. The condensers tested were filled with nitrogen up to 15-18 kg/cm^2 and with elegas up to 8-9 kg/cm^2. The tests showed that the use of elegas can lower significantly the pressure in gas-filled condensers (compared to nitrogen) or, if the same pressure is kept, can decrease the ~~size~~ dimensions or increase the capacitance significantly.

3. At high loads (for example, up to 2000 kva for a capacitance of 1200 $\mu\mu$f) the stabilized temperature of the condenser reached about 70°C without forced cooling, when the surrounding air was about 20°C.

The tests conducted show, as it appears to us, that elegas can be used exclusively to fill high-voltage condensers, especially for high-reactive powers and powerful high-frequency circuits.

In conclusion we wish to thank senior engineer A. I. Eylenkrig, who conducted the factory tests on high frequencies, and Director of the Kirov Factory Comrade I. M. Zal'tsman and Shop Foreman Comrade I. N. Strakovskiy, who built the condenser.

Submitted to Editorial
21 October 1941

/Appended figures follow/

Fig. 1 – p. 9
Fig. 2 & 3 – p. 11
Fig. 4 & 5 – p. 12

Zhurnal Tekh. Fiz., Vol. XII, No. 1
[Available in L/C].

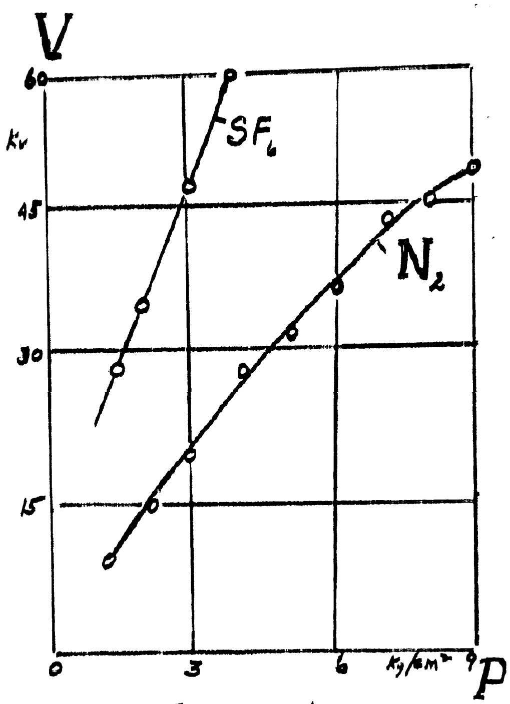

Figure 4.

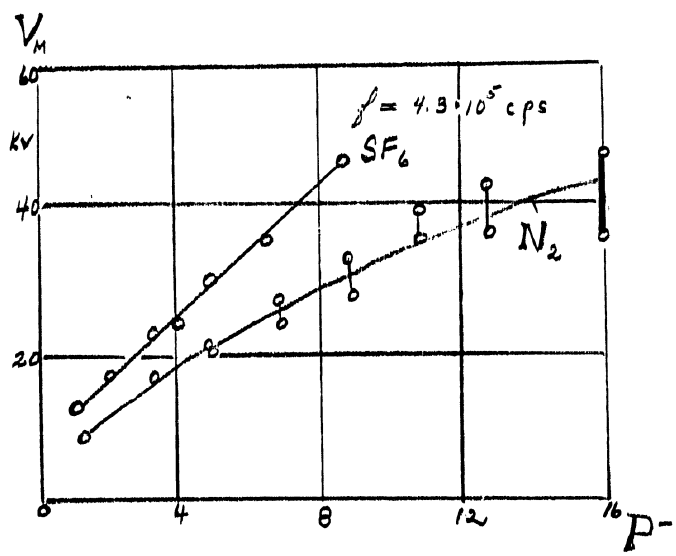

Figure 5.

- END -