and dc with a degree of distortion which is a function of the operating condition of the hvdc system.

A sufficient number of HVdc installations currently exist, are under construction, or are in the planning stages to warrant standardization efforts on many of the specialty equipments associated with HVdc converter stations such as the dc arrester. Specification preparation would be made easier and straightforward if applicable arrester standards were available. Replacement of arresters for whatever reason, including expansion of the existing system or facility, would also be made much more simple. Replacement of a failed arrester, either SiC or ZnO, with a gapless ZnO arrester, would be handled with similar ease to that with ac.

However, there exist a sufficient number of significant differences with ac arrester design tests to justify either a new standard or a major addition to the existing standard ANSI C62.11.

Discusser: R. S. Thallam

TABLE I
Design Test for HVDC Arresters for Recent LADWP HVDC Projects

	PIU	IPP	PIE
1.	**Current Sharing**	(1)	(1)
2.	**Discharge Voltage** - Steep current impulse - Lightning impulse - Switching impulse	(2)	(2)
3.	**Operating Duty Cycle**	(3)	(3)
4.	**Life Stability**	(4)	Accelerated Aging
5.	**Polarity Reversal***	---	Special Durability
6.	**DC-Bias Discharge**	---	---
7.	**Corona**	(7)	(7)
8.	**Pressure Relief**	(8)	(8)
9.	**Voltage Withstand** (Wet housing)	(9)	(9)
10.	**Contamination**	---	(10)
11.	**Seismic**	(11)	(11)
12.	---	---	Overvoltage Interrupting Capability

*Verification that #4 not adversely affected by polarity reversal. Therefore, since same supplier on IPP, the test on PIU was not repeated on IPP.

**Verification that discharge voltage not significantly changed by both dc voltage polarities.

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Influence of the Surrounding Medium and Service Behaviour of Metal Oxide Resistors for High Voltage Arresters

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Abstract—With reference to a direct use of metal oxide resistors as surge arresters without spark gaps, their behaviour in various gas atmospheres, such as can occur due to partial discharges inside the arrester, are considered and discussed. Attention is likewise paid to their behaviour in air with decomposition products and SF_6 with decomposition products. Furthermore, reports are given on investigations of complete MO surge arresters of a 110 kV system after several years in service, from aspects of gas composition and leakage current.

Discusser: P. Kirby

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Behaviour of Zinc Oxide Surge Arresters Under Pollution

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This paper presents results of pollution tests with A.C. voltages which were carried out with a multi-unit zinc oxide arrester. Zinc oxide surge arresters are exposed to heavy thermal and electrical stresses if the porcelain housings of the arrester units are polluted. Together with other environmental stresses such as temporary overvoltages or high temperatures this can lead to thermal runaway of the metal oxide arrester. In the past in pollution research of MOAs a lot of attention was paid to the coupling in of currents at the flanges of a multi unit arrester with the porcelain housings nonuniformly polluted. This has also been taken into account in the ANSI testing standard for pollution tests of MOAs. Although there is no generally agreed standard for pollution testing of MOAs most pollution tests are carried out according to the test procedures given in IEC 507 which only have been proved to be suitable to test the pollution performance of standard insulators.

During tests carried out according to the solid layer method it was observed that the formation of dry bands influenced the amplitude of the measured internal currents. Especially when there was only one dry zone near to one of the flanges of an arrester unit the temperature rise of the varistor column near the dry band was high. This was nearly independent of the presence of partial arcs across the dry zone. To investigate the influence of dry band formation on the stresses of the zinc oxide material a special test has been carried out with a single arrester unit. First the arrester housing was polluted and dried. Afterwards at a certain location on the porcelain housing a dry zone of about 10% of the total creepage length was formed artificially which was just large enough to prevent arcing across the dry zone. The A.C. test voltage was applied for several hours. During this test the internal and external currents were recorded.

Figure 1 shows the test arrangement with the estimated voltage distribution along the pollution layer and the inner varistor column with the dry zone at the bottom flange of the arrester.

At an A.C. test voltage of 68 kV no partial arcs were burning across the dry zone and at the pollution layer. The wetting of the dried pollution layer was accomplished by a relative air humidity in the test room of more than 85%. Because of the capacitive coupling between the varistor column and the pollution layer the current in the arrester discs is influenced by the voltage distribution along the external pollution layer. This leads to locally higher stresses of the varistor elements. The highest internal stresses are at the location of the dry zone, where the internal current is about 4 times higher than under clean conditions.

In addition to the measurements of currents the maximum temperatures during the above described tests were recorded by means of thermostrips attached at different locations along the varistor column. In figure 2 the temperature distribution along the varistor column after a test duration of 2 hours is shown.

It can be seen that with the dry zone at the flanges the maximum temperature reaches about 85°C.

In addition to the temperature rise due to the higher internal currents the different voltage distribution inside and outside of the arrester causes a high radial electric field between the varistor elements and the porcelain housing. This can lead to internal discharges which might damage the varistor elements if they are not properly coated. The presence of these internal discharges can be checked measuring the internal current at the bottom flange. Internal discharges are indicated by impulsive currents superimposed to the A.C. current. This method can be used to compare different arrester designs in respect to their internal insulation system and internal discharges caused by pollution.

Besides the laboratory tests the behaviour of polluted metal oxide arresters was investigated by a simulation model which allows to calculate the internal and external currents of a polluted arrester unit. Also the effect of internal discharges on the calculated current signals could be considered. The calculated curves showed a good agreement to the currents measured during the laboratory tests.

Because the above results have shown that the critical stresses for polluted MO arresters are not always covered by the standard pollution test procedures a new test procedure is suggested which should complete or even substitute other test procedures. This new test consists of a check of thermal stability during a long duration pollution test with the arrester under test polluted nonuniformly. During this test internal discharges are detected by measuring the internal current at the bottom flange. The evaluation of the power dissipation of the arrester under clean conditions before and after the pollution test allows to recognize any damage of the varistor elements due to internal discharges.

Discusser: Y. I. Musa

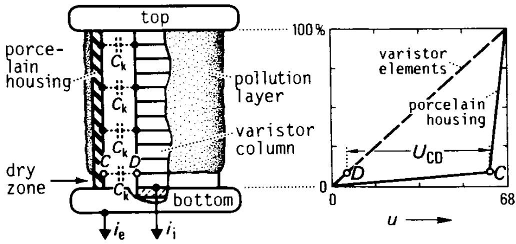

Fig. 1. Influence of dry band position on the internal radial electric field.

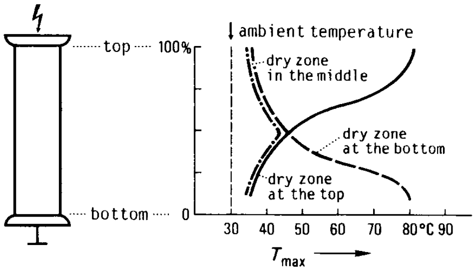

Fig. 2. Temperature distribution along the varistor column of a single arrester unit with different dry band positions.

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Electrical Performance of Polymer Housed Zinc Oxide Arresters Under Contaminated Conditions

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The electrical performance of polymer housed zinc oxide distribution arresters has been investigated in a fog chamber. Two types of housing materials, namely, copolymers of ethylene and propylene (commonly known as EPM rubber) and terpolymers of ethylene propylene and diene (commonly known as EPDM rubber), both containing alumina trihydrate (ATH) filler, have been examined. It has been demonstrated that under relatively low (250 μS/cm) and moderate (1000 to 2000 μS/cm) fog conductivity, degradation in the form of tracking and erosion of the housing occurs. On some housings, degradation is dominant in the region of the mold line and is due to nonuniformity in filler dispersion. The electric field has been computed and possible electrode modifications to improve the surface electric field distribution are suggested.

Table 1 shows the details of the samples evaluated. Some of the samples used were complete arresters with zinc oxide disks and some were polymer housing only. The complete arresters were tested along with the insulated mounting bracket. They were fixed to a wooden post and placed in the center of the chamber. The housings were attached to stainless steel electrodes and suspended from a plexiglass ring fixed to the roof of the chamber. The electrodes for the housing were carefully machined and inserted in the central cavity using silicone grease in order to prevent water from entering the cavity.

Table 2 shows the results obtained at various water conductivities.

The electric field distribution was computed using a Finite Element method based computer program "POISSON", developed by Los Alamos National Laboratory. The maximum number of mesh points allowed by the program is limited to 60,000, which was adequate for the present study. To improve the accuracy of computation, a variable mesh size was used, the region near the HV electrode having a greater mesh density than other parts of the arrester.

6. Conclusions

1. This study demonstrates that the polymer housings used presently for zinc oxide arresters can exhibit tracking and erosion at low and moderate values, but not at very low and moderate values