Superconducting RF Activities at KEK*

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Introduction

At the last RF SC Workshop at Argonne National Laboratory in 1987, we reported some of the early results of tests for TRISTAN superconducting cavities[1]. Fabrication and tests of five-cell niobium cavities have been continued since then and sixteen five-cell cavities have been installed in the TRISTAN tunnel in summer of 1988. We have reported[2] the performance of these sixteen cavities and the results of the early beam operation at the 1989 Particle Accelerator Conference at Chicago.

Before the installation of superconducting cavities, TRISTAN has been operating with 104 nine-cell normal-conducting cavities with the maximum beam energy of 28.5 GeV. By adding the superconducting cavities, the beam energy has been upgraded from Autumn of 1988 to 30, 30.4 and then 30.7 GeV.

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The second sixteen five-cell cavities have also been fabricated, tested and installed in the tunnel at the beginning of August 1989. Cool down and commissioning of the cavities will start at the middle of October, and from November beam energy will be pushed up to 32 or 33 GeV. Fig. 1 shows the string of cryostats installed in the TRISTAN tunnel.

In this paper we report the test results of thirty-two 5-cell cavities before installation in the tunnel, and some of our experience of the beam operation of the first sixteen 5-cell cavities. Details of the beam operation will be reported by our colleagues from KEK in this workshop[3),4)]. The cryostats[5)], cryogenic system[6)], cavity fabrication process[7)] will also be reported in this workshop.

Vertical and horizontal tests

All cavities were tested at first in a vertical cryostat without couplers and frequency tuners just after the last surface treatment.

Fig. 2 shows the statistics of accelerating field gradient obtained in the vertical tests without RF couplers and frequency tuner for thirty-two five-cell cavities. About two-thirds of whole cavities reached to the fields closed to or beyond 10 MV/m. Beyond the accelerating field of 10 MV/m, usually we stop the test because of too much heating of the cavity and boiling off of liquid helium in the cryostat.

Fig. 3 is also for the results of vertical tests showing the field strength for each cavities from #1a to #16b and the range of field where the emission electrons above 1 nA were detected by a biased pickup probe. For about half of whole cavities emission electrons were not observed even at their highest field level.

Fig. 4 and Fig. 5 show the increasing RF losses of cavities plotted against square of field. Cavity #7b shows almost linear increase of losses against square of field and cavity #8a shows additional exponential increase of losses starting at some threshold field due to electron emission. Fabrication process of these two cavities are quite similar and we do not understand the reason of such difference.

As is seen from these results, it is still not yet clear how to control the cavity surface to get field gradient of 10 MV/m stably for all cavities. This is the important subject we should solve for the next large scale application. But it is also obvious that the cavity performance has been improved during the past few years. It is due to the quality improvement of niobium, careful checking at all stages of cavity fabrication, mechanical smoothening by buffing or grinding of whole area of inner surface including the under-beads of electron beam welding seam, improvement of electro-polishing and rising technique and clean environment for assembling.

After the vertical test, two 5-cells were combined and assembled in horizontal cryostats with input coupler, HOM couplers and frequency tuner.

Most of the assembling of cavity is done in the clean room of class 100 as seen in Fig. 6, but the assembling of horizontal cryostats is inevitably done outside of the clean room, so portable type plastic boxes with filter and fan are used to assemble the input couplers and gate valves. Number of dust particles in the plastic boxes show the cleanliness of class 1000 to 10000 depending on the working condition, they are shown in Fig. 7 and Fig. 8.

The assembled pairs of 5-cell cavities were tested in the horizontal position with high power RF system, the results are shown in Fig. 9 and Fig. 10. If we compare these results with that of vertical tests, about 30 % degradation for both E_{acc} and Q-value are seen. It might be due to several times exposure to one atmospheric pressure during the assembling having the risk of taking dusts into the cavity. This is another big problem to be improved.

Beam operation of superconducting cavities

From November of 1988, sixteen 5-cell cavities have been operated for storage and acceleration of electrons and positrons in the TRISTAN main ring. Cavities have been kept at helium temperature for 5000 hours and used for high energy experiments for 3000 hours, showing that superconducting cavities can be operated stably in the high energy e^-e^+ storage ring satisfactorily. Several problems which we have experienced in the SC-RF system of TRISTAN during the beam operation of nine months are also discussed in this workshop[3),4)].

Future plan

There are of course wishes of physicists to push the beam energy up to more higher, then we will replace the conventional cavities in the tunnel with superconducting cavities. On the other hand, there are opinions to go to higher luminosity with the present beam energy. In this case we should probably try to improve the power handling capability of input and HOM couplers.

R&D of high Tc material and sputtering technique for radio-frequency application will also be other subjects of our group, some early work[8)] on high Tc material is presented in this workshop.

Acknowledgements

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We also thank the members of Accelerator Department for great help to accomplish the upgrading of TRISTAN.

References

1) T. Furuya et al., Proc. Third Workshop on RF Superconductivity, 1987, Argonne, Illinois, USA (1988) 95.

2) Y. Kojima et al., to be published in Proc. 1989 Particle Accelerator Conference, 1989, Chicago, Illinois, USA.

3) K. Akai et al., this workshop.

4) S. Noguchi et al., this workshop.

5) S. Mitsunobu et al., this workshop.

6) T. Ogitsu et al., this workshop.

7) K. Saito et al., this workshop.

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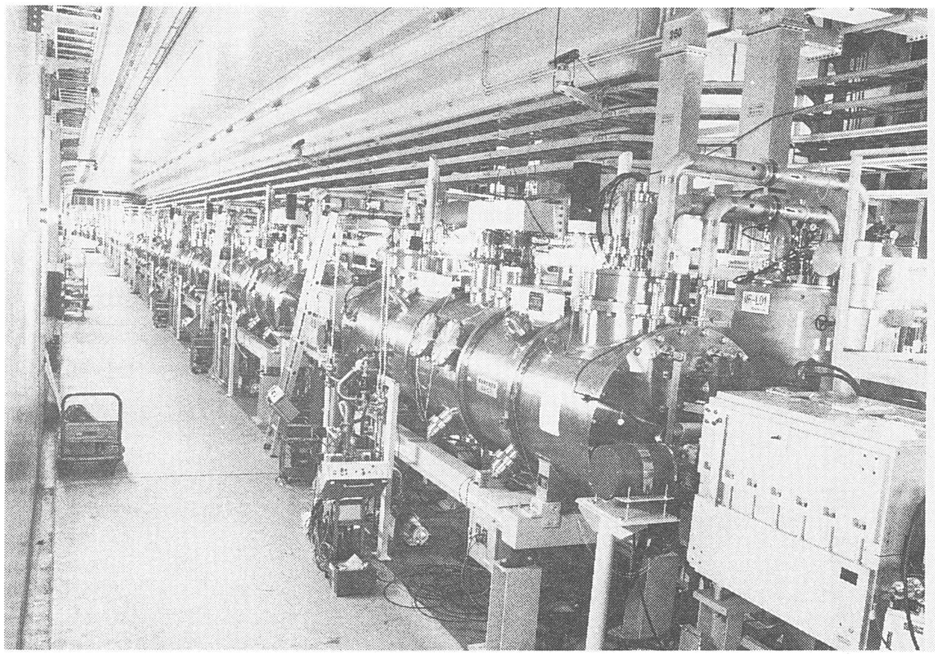

Fig.1 The string of cryostats for SC–RF cavities installed in the TRISTAN tunnel.

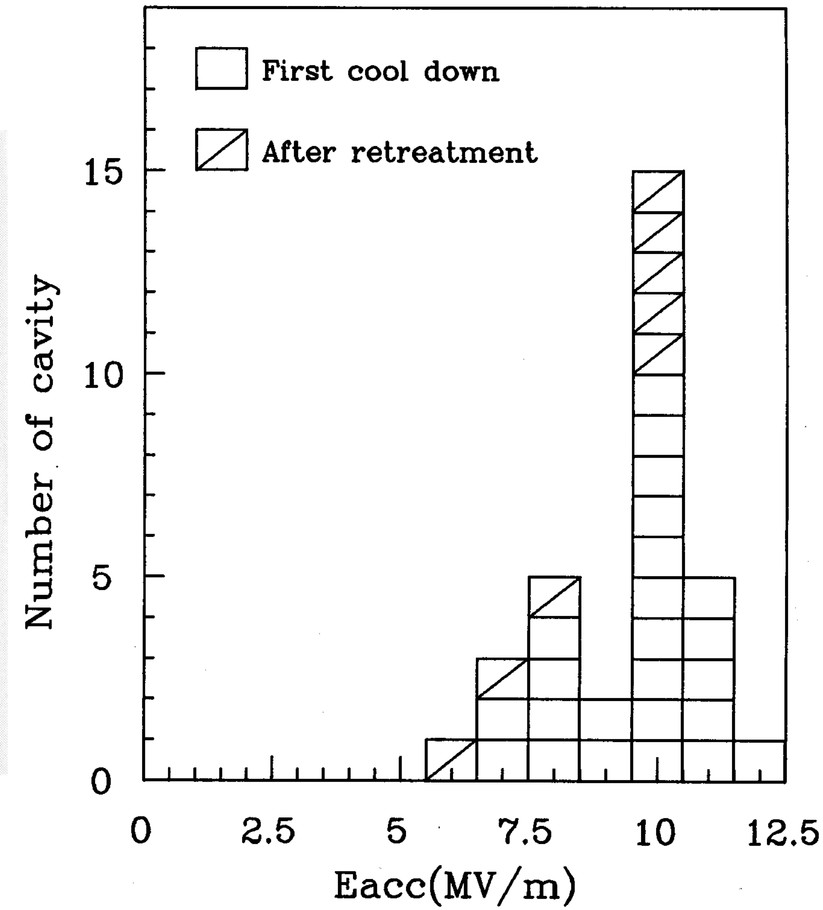

Fig.2 Distribution of accelerating field gradient of thirty–two 5–cell cavities in the vertical tests.

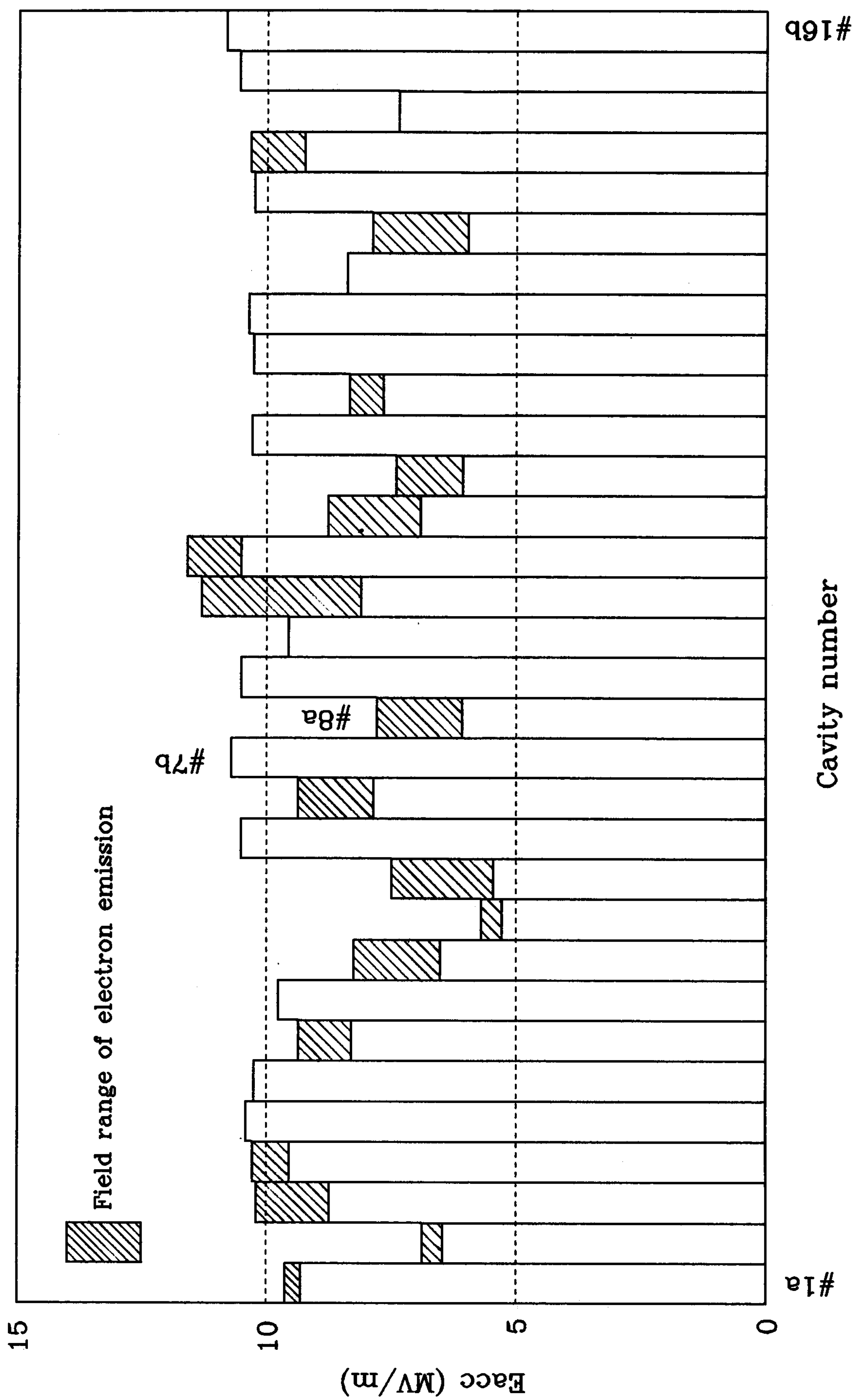

Fig.3 Statistics of maximum field strength and field range of electron emission in the vertical tests.

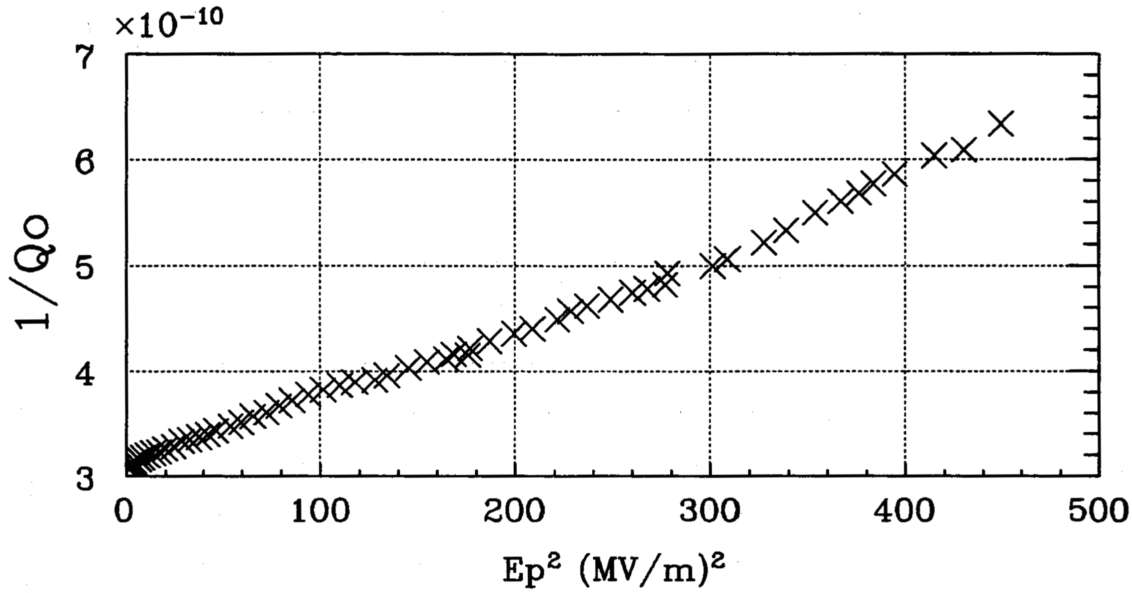

Fig.4 RF losses against square of peak surface field (Cavity #7b).

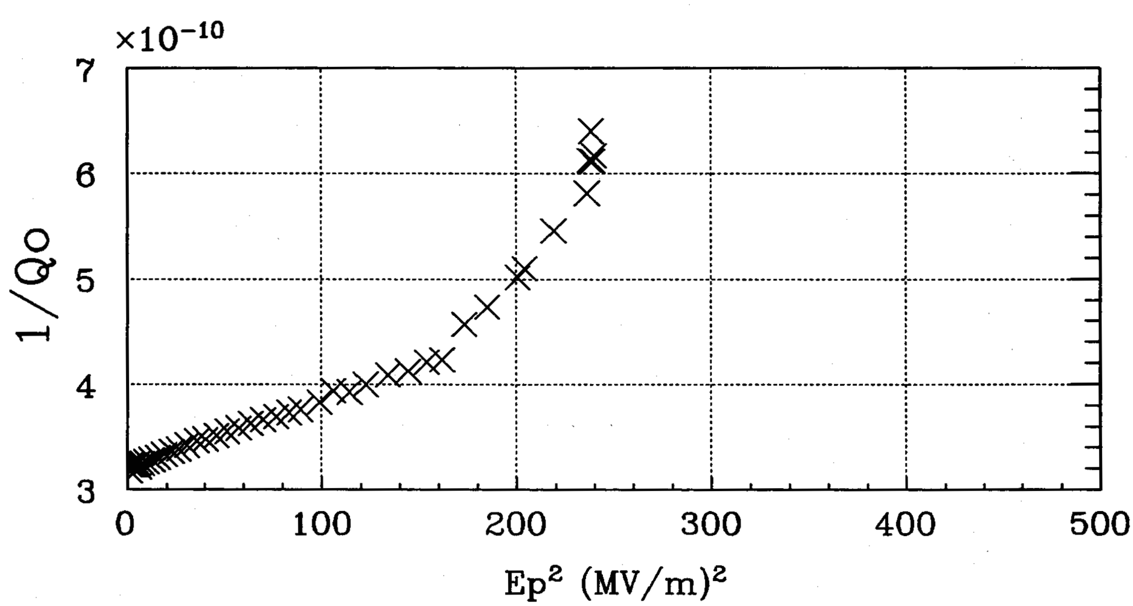

Fig.5 RF losses against square of peak surface field (Cavity #8a).

Fig.6 Cavity assembling in the clean room.

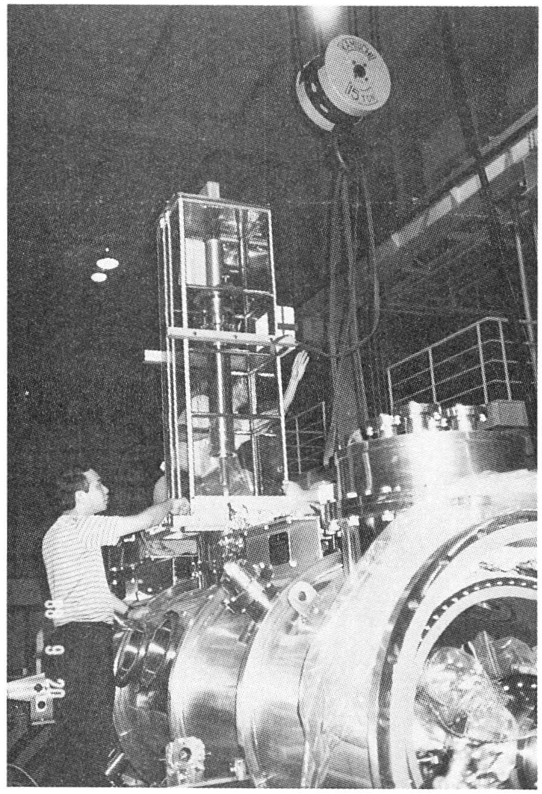

Fig.7 Portable plastic clean box for input coupler assembling.

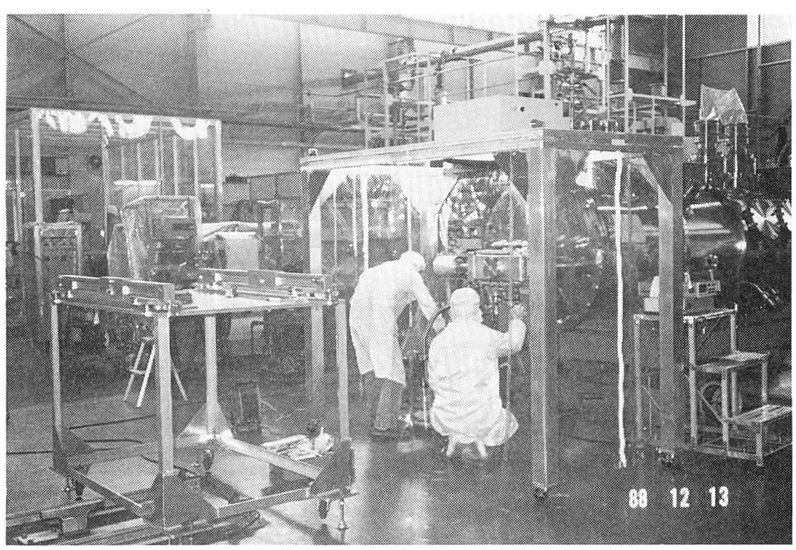

Fig.8 Portable plastic clean box for gate valve assembling.

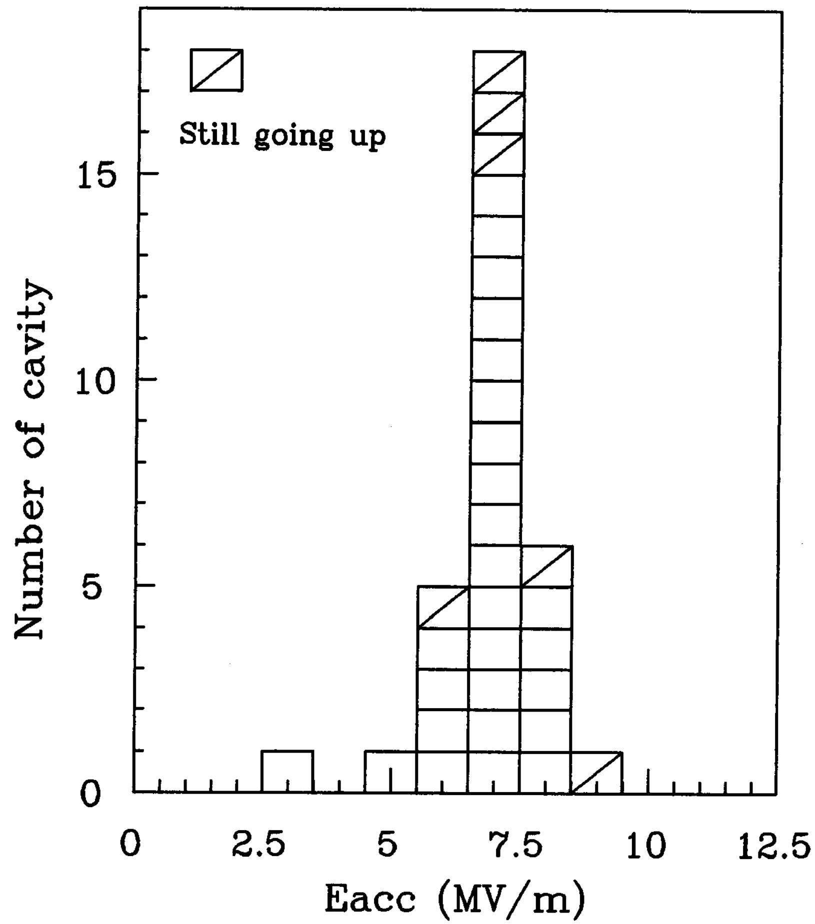

Fig.9 Distribution of accelerating field gradient of thirty-two 5-cell cavities in the horizontal tests.

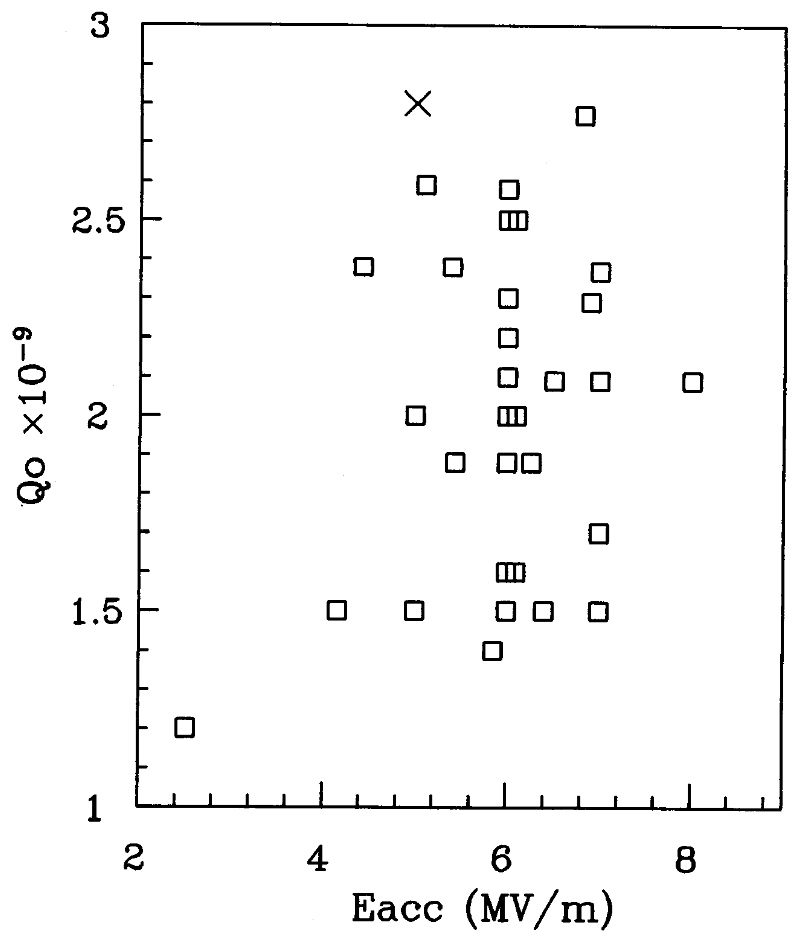

Fig.10 Distribution of Qo observed in the horizontal tests, cross denotes the average value of the vertical tests.

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