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TEST TANK FOR FAK MAGNET MODULES

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There exists a round test tank (drawing No. 2A21.700.0) to test FAK magnet modules vacuum-wise and electrically.

For vacuum tests the tank is equipped with two 400 ℓ/sec ion sputter pumps and a turbo-molecular group. This group can be closed off with a butterfly valve. Several pressure pick-up points are provided as well as a nitrogen inlet valve. For all sealing rubber joints are used.

1. HOW TO TAKE A MAGNET MODULE OUT OF THE TEST TANK

The tank is assumed to be under vacuum and the magnet to be pulsed.

1.1 Stop all pulsing of the magnet. Secure system and connect generator straight into terminating resistor.

1.2 Switch electron gun off if it was used.

1.3 Stop both ion pumps and chart recorder.

1.4 Switch off all pressure pick-ups, wait 5 min.

1.5 Close butterfly valve for turbo group, stop turbo and primary pumps.

1.6 Fill tank slowly with dry nitrogen to atmospheric pressure using the special inlet with valve on tank cover. Do not fix the nitrogen connection; it will hold itself in position because it is under suction. This method avoids the risk of pushing out the movable arm and blowing off the glass oscilloscope screen when the tank pressure gets higher than atmosphere.

1.7 Disconnect earth connection and all other leads to the tank cover.

1.8 Lift tank cover off complete with ion pump. Secure ion pump with lifting tackle. The system is top-heavy, attention!

1.9 Unscrew large top hat which carries the electrical feedthrough (2A21.721). Press out top hat with the screws provided and pull feedthrough clear of strip-line connections.

1.10 Unscrew blanking flange on moving arm top hat (2A21.727).

1.11 Take electron gun or magnetic probe out.

1.12 Screw 4 eye bolts into top of magnet frame and lift magnet carefully out.

1.13 Put magnet into a plastic bag. This bag must be filled with dry nitrogen and then sealed.

2. HOW TO LOAD A MAGNET MODULE INTO THE OPEN TEST TANK

2.1 Points 1.7 to 1.12 must be executed in reverse order.

2.2 If all electrical and vacuum connections are made pumpdown can start and the pumpdown curve be taken (tank pressure as a function of time).

2.3 Start primary pump of turbo group and open butterfly valve.

2.4 Start turbo pump when pressure drops below 6 Torr.

2.5 Start ion pumps and chart recorder when pressure drops below 5×10^{-5} Torr.

2.6 The electron gun heater may be outgassed as described under point 3.2.2 if the vacuum is permanently better than 10^{-5} Torr.

2.7 Electrical conditioning of the magnet module can be started when the vacuum is better than 10^{-6} Torr. The conditioning procedure is described under point 3.1.

3. ELECTRICAL TESTING OF A MAGNET MODULE

3.1 Conditioning

After a magnet module has been newly assembled and vacuum-tested it must be electrically conditioned. Every time a magnet has not been pulsed for a very long time or the vacuum has been broken, a limited conditioning process is imperative.

The conditioning is a careful procedure to clean a magnet of dust particles and small mechanical imperfections with relatively low voltage, short duration pulses (to limit the eventual damage). The effect is an improved electrical breakdown strength of the magnet metal-vacuum interfaces.

3.1.1 Conditioning should not start before the vacuum is better than 10^{-6} Torr.

3.1.2 Conditioning should start with a PFN voltage of not more than 40 kV, pulse lengths ~ 200 nsec, single shot, i.e. one shot/2 sec.

3.1.3 If hold off is good, the pulse length can very slowly be increased to 2100 nsec.

3.1.4 If point 3.1.3 is satisfying, the pulse duration must be reset to 200 nsec and the voltage may be raised.

3.1.5 Carry out points 3.1.3 and 3.1.4 until 80 kV PFN are reached.

3.1.6 If the breakdown behavior is good the magnet is conditioned and multishotting may start.

3.1.7 If the breakdown rate is high it may be for several reasons:

i) The magnet is full of dust and conditioning was done too fast. A more careful procedure should be adopted.
ii) There are mechanical imperfections which cannot be cured by simple conditioning.
iii) Not the magnet but possibly the feedthrough insulator will not hold the voltage.
iv) The magnetic probe or the electron gun is not mounted correctly.

In all cases it is probably best to open the tank and inspect all details.

3.2 Electrical measurement and diagnostics

A movable arm is mounted on the tank reaching into the vacuum which may be displaced horizontally. On this arm either a probe for magnetic field measurement (holder drawing 2A21.735) or an electron gun for remanent field measurement (holder drawing 2A21.731) may be mounted. To change one for the other the vacuum must be broken (a blanking flange must be taken off) and the holder must be changed in the arm sub assembly.

Other pick-ups are mounted in the oil insulated connection box where adaptation is made between the two cables in parallel to a single feedthrough. One of each of the cable sockets for input and output carries a capacitive pick-up whose output connection is via a BNC socket.

3.2.1 The magnetic probe

The probe is of strip-line configuration (vacuum dielectric except for small spacers) and is short-circuited at one end. Its characteristic impedance is 75 Ω. The probe is made from copper strips of 10 × 1 mm section with 4 mm separation.

Its output flux is ~ 64 μV sec for 150 Gm, i.e. for a pulse of 40 kV amplitude via a FAK module into a 15 Ω terminator.

The probe must be well aligned horizontally and vertically in the magnet aperture to avoid the risk of high-voltage flashover. The output from the probe should be connected via a good quality 75 Ω cable to a scope and be terminated there with a 75 Ω/2 W resistor. The signal thus obtained is the dϕ/dt of the magnetic kick. Its peak level will be ~ 1.4 kV for a 40 kV pulse. Therefore a ×10 probe with a BNC front end should be used if the dϕ/dt is to be observed. To see the kick waveform directly the signal must be integrated. An integrator with a time constant of 160 μ sec has been found most useful, giving a signal of ~ 350 mV amplitude with minimal droop for 40 kV pulse voltage.

3.2.2 The electron gun

The electron gun is mounted on a shaft which can easily be fixed to the movable arm. When mounting the gun a minimum separation of 20 mm between the gun shield and the magnet plates should be respected to avoid HT flashover. The electrical connections inside the tank are made via four highly flexible porcelain bead isolated wires with different size multicontacts. After these have been plugged in, the movable arm is adjusted such that the gun is pointing horizontally to the centre of the aperture before the blanking flange is mounted. The external gun connections are permanently fixed to a special electron gun chassis in which all necessary supply voltages are derived. This chassis is supplied by a 10 kV d.c. Brandenburg generator, the output voltage of which must be negative because of the grounded anode configuration of the electron gun system. An oscilloscope screen is permanently fixed to the test tank. There the cathode-ray spot can be observed for adjustment and photographed for measurement. A camera holder is provided to fix a standard Tektronix camera to the tank.

Every time after the electron gun has been subjected to atmospheric pressure the heater filament must be reconditioned. This is done without Brandenburg HT! The electron gun may only be powered when the vacuum is better than 10^{-5} Torr. To outgas the filament the heater current is increased every 5 min by 2 A up to a maximum of 8 A.

The normal running current is between 5 and 6 A, depending on the spot size desired. The normal Brandenburg voltage is -5 kV.

The remanent field is measured by pulsing the magnet for at least 30 min before the field sense is changed. This must be done several times. Before every change the cathode-ray spot must be photographed. After several reversals the alignment of the gun can be verified and the remanent field be determined from the photo. Taking a cathode voltage of 5 kV and the physical disposition of the gun arrangement the formula for the remanent field B becomes

$$B_{rem} = 0.0424 \times D \text{ gauss},$$

where D is the deflection from the centre to the spot in mm.

3.2.3 Capacitive pick-up rings

These pick-ups monitor the input and output voltage pulses of the magnet. Each should always directly be terminated at the output BNC by 75 Ω. Integrated and double terminated the signals give a good approximation of the actual voltages at magnet input and output striplines. In addition, the time difference between the two signals is related to the magnet transit time in a simple manner.

Output characteristics: An integrator with a time constant of ~ 12 μsec will give a signal of ~ 0.8 V for 80 kV PFN.