PREFERRED
RELIABILITY
PRACTICES

MONITORING SPACECRAFT EXPOSURE TO MAGNETIC FIELDS

Practice:

This reliability practice provides a read out of magnetic field exposures which could adversely affect the magnetic cleanliness of the spacecraft. When transporting a spacecraft or flight instrument to a launch site or other facility, monitor the D.C. magnetic field peak exposure with a "tell tale" sensor. This practice is also applicable to flight hardware placed in storage for extended periods.

Benefit:

The "telltale" device will provide an indication of the peak D.C. magnetic field intensity to which the transported (or stored) system has been exposed. High residual fields are sometimes caused by nearby lightning strikes, power system faults or exposure to strong permanent magnets. Compliance with the peak magnetic field exposure, as defined in the Magnetic Control Plan document, assures that the flight hardware is in its lowest magnetic state, thereby minimizing any adverse effects on the integrity of science data.

Programs That Certified Usage:

Apollo, Pioneer, Mariner Venus '67, Voyager, Galileo

Center to Contact for Information:

Jet Propulsion Laboratory (JPL).

Implementation Method:

JPL uses a version of the "telltale" sensor devised by the Ames Research Center to verify compliance with the magnetic control imposed on the Apollo program and by the science requirements for the Pioneer spacecraft. This 3 cm cubic sensor is comprised of 3 orthogonal *Dumet* wires (20 AWG, approximately 5 cm long) embedded in a plastic block (provided with a ground strap to avoid electrostatic discharge). The block is demagnetized in a near zero field environment and the net magnetic moment is measured in the earth's field (0.05 mT)* and at several intermediate points up to a maximum exposure of 2.5 mT (25 Gauss). After a demagnetization, the device is ready for use. For practical considerations, the device characteristics are expressed in terms of the observed effect of field exposure, i.e. magnetic field in nanoTeslas (nT) produced at a distance of 0.3 meter (12 inches) from the telltale. Figure 1 shows a sample calibration.

* Typical value at mid-latitudes (0.5 Gauss), Gauss = 10^{-4} Tesla, mT = milliTesla.

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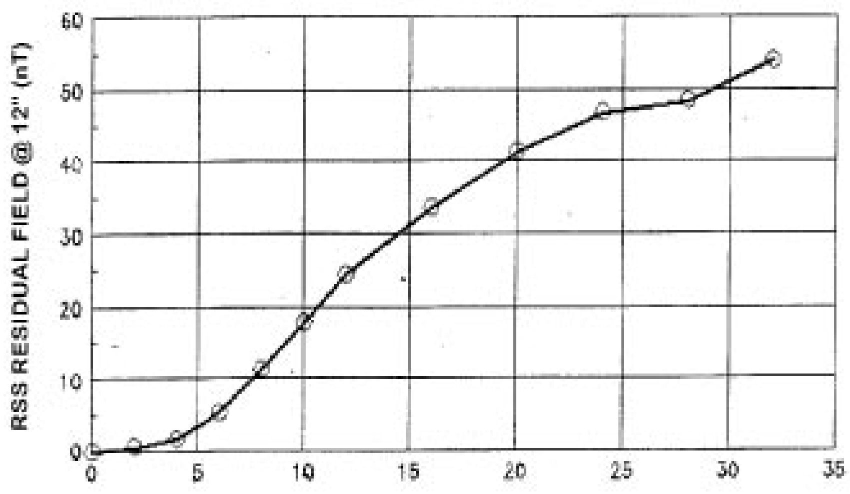
FIGURE 1

CALIBRATION CURVE OF SSI MAGNETIC RECORDER



Given the measured field exposure characteristics for peak exposure of the device, subsequent measurements are indicative of the maximum field exposure since the last demagnetization. Sample results are indicated in Table 1, where the maximum field exposure was less than 0.3 mT (3 Gauss).

Table 1: Magnetic Exposure Recorder, Sample Results

Serial Number	Measured Magnetic Field @ 0.3 m (12")*		
	X-Axis	Y-Axis	Z-Axis
SN 003	<1	1	1
SN 002	1	1.5	1
SN 001	<1	<1	<1
SN 009	2	1	<1

*(nT, peak to peak)

Typically, 4 to 6 sensors are mounted around the perimeter of the system being monitored. At significant points in the processing of the flight hardware, the sensors are removed for measurement, demagnetized, and returned to their initial locations. In the event that excessive field exposure is detected, cognizant hardware personnel can determine if the flight hardware being monitored requires demagnetization. Knowledge of the locations of the sensors, their relative field exposure, and the hardware processing performed since the last measurement can aid in the identification of the source of the magnetization and in determining if the spacecraft needs localized demagnetization.

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An example of the use of this device is the transport container for the Galileo spacecraft. Four sensors were located on the inside of the truck container wall around the spacecraft. Two sensors were mounted ahead of the spacecraft on the right and left side wall and two more were mounted behind the spacecraft. Thus, the sensors would be more exposed than the spacecraft to any external magnetic field that might pass by the transport truck. At the end of the cross country trip, none of the twelve magnetizable rods showed any evidence of exposure to an excessive magnetic field.

Technical Rationale:

Because it is impractical to completely eliminate the use of ferromagnetic materials on spacecraft and flight hardware, it is important to control the maximum magnetic field exposure for hardware used on those missions for which a magnetic control plan has been implemented. In most cases, a magnetic control plan is required for missions which have a science magnetometer or a plasma wave experiment as part of the payload.

Verification of compliance with the specified maximum field exposure is difficult because not all sources of strong magnetic fields are obvious, and there is no sensual perception of magnetic fields in the range of interest for spacecraft concerns, 0.1 to 2.5 mT (1 to 25 Gauss). In addition, the time interval over which monitoring may be required can be very long-- particularly if the flight hardware has to be shipped over long distances or placed in storage. Hence, a passive sensing device is needed.

Dumet, a ferromagnetic alloy, has mechanical properties which make it suitable for applications such as component leads requiring a hermetic seal to glass. An ancillary characteristic of this material is a high magnetic permeability. This property, coupled with the fact that the material is available in the form of small diameter wire, makes it suitable for use in the fabrication of the "telltale" sensors. Alternate materials include Kovar and ferrites.

Impact of Non-Practice:

If there is no process in place to monitor the magnetic field exposure of flight hardware between integration and launch, there is no assurance that high permeability materials are in their lowest magnetic state. Magnetized components could result in erroneous magnetometer experiment data or other adverse effects.

Related Practices:

1. *Magnetic Design Control for Science Instruments*, Practice No. PD-ED-1207
2. *Demagnetization of Ferromagnetic Parts*, Practice No. PD-ED-1220
3. *Magnetic Field Restraints for Spacecraft Systems and Subsystems*, Practice No. PD-ED-1222

References:

1. "Assessment and Control of Spacecraft Magnetic Fields", NASA SP-8037, September 1970.