



WORKING PAPER

**DANGEROUS GOODS PANEL (DGP)
MEETING OF THE WORKING GROUP OF THE WHOLE**

Auckland, New Zealand, 4 to 8 May 2009

Agenda Item 2: Development of recommendations for amendments to the *Technical Instructions for the Safe Transport of Dangerous Goods by Air* (Doc 9284) for incorporation in the 2011/2012 Edition

2.2: Part 2 — Classification

MAGNETIZED MATERIAL

(Presented by Dangerous Goods Advisory Council)

SUMMARY

This paper provides a summary of findings relative to magnetized material.

Action by the DGP-WG is in paragraph 7.

1. INTRODUCTION

1.1 The Dangerous Goods Advisory Council (DGAC) is undertaking a comprehensive analysis of requirements for magnetized materials (see Part 2;9.2.1 d) and Packing Instruction 902). The focus of DGAC's effort is to evaluate the range of magnetic field strengths that should be regulated in order to ensure proper operation of aircraft navigational instruments. Based on its analysis, DGAC believes that regulation of magnetized material at levels currently regulated by the Technical Instructions is unwarranted.

1.2 The requirements for magnetized material in Part 2;9.2.1 d) and Packing Instruction 902 permit magnetized materials with strengths between a lower and upper limit to be transported onboard an aircraft. These limits are commonly expressed in three different ways as follows:

ICAO magnetized material limits	A/m	Gauss	Compass deflection
Lower limit @ 2.1 m (7 feet)	0.159 A/m	0.002 Gauss	½ Degree
Upper limit @ 4.6 m (15 feet)	0.418 A/m	0.00525 Gauss	2 Degrees

1.3 The working group may recall that the issue of amending the Technical Instructions' magnetized material requirements was raised at the Dangerous Goods Panel (DGP) meeting in November 1999 (DGP/17) in WP/59 by the panel member nominated by the United States. Consistent with United States domestic air transport regulations, the proposal was to limit regulation of magnetized materials to those with a field strength of more than 0.418 A/m at 15 feet and that such materials should be forbidden from air transport or shielded to reduce the field strength below the threshold level.

1.4 The concern remains that many metallic pieces of equipment become magnetized unintentionally. The Technical Instructions' text recognizes that this may be the case with automobiles, automobile parts, metal fencing, piping and metal construction material. In addition, it is also the case with computer systems and computer racks with metallic frames, including certain computer systems installed on aircraft. Other examples include a portable dishwasher and a tool chest. The added cost associated with transporting such items as magnetized material may be significant and DGAC questions the safety benefit.

1.5 The proposal to DGP/17 (see Appendix A to this working paper) was not adopted based primarily on comments by the IFALPA panel member who noted that there were still large numbers of older aircraft used for cargo transport that were dependent on magnetic receptors. The IFALPA representative expressed the opinion that a comprehensive study should be undertaken before the panel considered any action. The DGAC study on magnetized material is intended to fulfil the IFALPA recommendation.

1.6 Preliminary DGAC findings are as follows:

- a) magnetized material requirements were first introduced in air regulations in 1962 out of concern for the operation of the magnetic compass installed in the aircraft cockpit;
- b) the compass is the only aircraft instrument known to be affected by magnetized material;
- c) airworthiness requirements for commercial aircraft permit a 10 degree tolerance of the compass reading compared to the 2 degree deflection permitted for magnetized material loaded aboard an aircraft;
- d) the compass may be used as a check of runway heading but compass heading is not normally used for purposes of air navigation;
- e) the compass is not regarded as an essential instrument in minimum equipment lists for known aircraft types meaning that the aircraft is permitted to operate even though the compass is inoperative;
- f) compass direction is also provided on aircraft built after 1955 by one or more gyroscopically stabilized magnetic direction instruments (gyrocompass) which normally read the direction of earth's magnetic field from a remotely located device in the wing or the tail of the aircraft. These devices are far less sensitive to magnetic material carried as cargo on aircraft;
- g) United States air transport regulations have, since 1985, not regulated magnetic materials at the level regulated by the Technical Instructions without any reported accident;

- h) many international shippers and carriers appear to only treat magnetized material as regulated if it exceeds the 2 degree at 4.6 m criteria;
- i) while vehicles, appliances, and even shipments using steel cylinders or steel boxes may meet the ICAO magnetized material criteria, they are not known to commonly be treated as magnetized material for purposes of air transport;
- j) obtaining reliable and repeatable results for magnetized materials in the range covered by the Technical Instructions are difficult to obtain so that opinions may differ on whether or not an item is or is not subject to regulation;
- k) the Technical Instructions' required separation distance (maximum of 4.6 m) for magnetized material is frequently provided by design, since in the case of many aircraft types, the compass is located approximately 4.6 m from the closest cargo location.

1.7 Based on the above information, DGAC believes that it would be more appropriate to limit regulation of magnetized material to those items which produce a compass deflection of 2 degrees or more at 4.6 m. This could be accomplished, as done by United States air transport regulations, by prohibiting magnetic goods with a higher field strength from being transported by air unless they are shielded. The above findings are discussed in more detail below.

2. HISTORY OF MAGNETIZED MATERIAL REQUIREMENTS

2.1 Magnetized material requirements have their origin in regulations that predate the Technical Instructions. Early requirements for magnetized material first appeared in 1962, almost coincidentally, in the IATA Restricted Articles Regulations (IATA RAR) and United States regulations for air transport of hazardous materials. It is assumed that development in the two regulations was coordinated. The 1962 preamble to the United States regulation identified the intent of regulating these materials in noting:

“Air shipments of magnets and magnetic devices can adversely influence the accuracy of magnetic compasses unless they are properly packed and kept at a safe distance from the aircraft’s compass. In order to safeguard the navigation of the aircraft, it is necessary to require the shippers of magnetic materials to mark clearly any packages containing magnetized materials and to install keeper bars...to prevent the magnetic field from adversely affecting the magnetic compass.”

2.2 In 1969, IATA began defining magnetized material as a material with a strength of 0.002 gauss or more at 2.1 m (1/2 degree compass deflection) and in 1974 the United States Federal Aviation Administration in an advisory circular first identified magnetized material with a strength of up to 0.00525 gauss reading at 15 m (2 degree compass deflection) as a level acceptable for air transport. The rationale for either of these values is no longer available. The two values were subsequently combined by both IATA and the United States to become the defined range of acceptable magnetic strengths regulated for air transport. This range was subsequently adopted into the Technical Instructions.

2.3 In 1985, the United States made a significant change to its regulations by deregulating magnetized material with strength of less than 0.00525 gauss reading at 15 m, noting:

“[It] believes the current rules on magnetic materials are obsolete due to the improvements in technology over the past 30 years. Modern aircraft use electronic compasses with magnetic compasses as backups. The sensors for the magnetic backup compasses of modern aircraft are located so far away from cargo bays so that the possible marginal magnetic properties of metal objects such as automobile parts will not cause a magnetic deflection effect on the compass. It is normal procedure for pilots to check the aircraft’s magnetic compass and electronic compass against runway heading before takeoff.”

2.4 DOT went on to note the difficulty in measuring low magnetic strengths (i.e. strengths below the 0.00525 gauss level at 15 feet). They noted that field strengths and directions could change with changing orientations of metallic parts and concluded:

“Consequently, these levels at low gauss levels are not repeatable and the necessity for and the benefits of regulating metallic loadings at low levels of magnetism is questionable.”

2.5 As a complement to the regulatory change, in order to address concerns for older aircraft built before 1955 (presumably aircraft not fitted with a gyro stabilized compass), the FAA issued an advisory circular recommending:

“If the aircraft being used does not have the magnetic compass master unit in a remote location and amply distant from the cargo hold, it is recommended that a special aircraft swing and compass calibration be made after loading and prior to operation.”

3. THE MAGNETIC COMPASS

3.1 While modern aircraft are still required to be fitted with a magnetic compass, requirements for the compass are informative as far as understanding the role of the compass in air navigation.

3.2 Beside cargo effects, the accuracy of a compass on an aircraft is affected by electromagnetic effects caused by the aircraft’s avionic equipment and rotary motion from aircraft engines, as well as by metallic objects within the cockpit such as the yoke. In addition to the compass located in the cockpit, aircraft are required to be fitted with at least one (usually two in the case of larger aircraft) gyroscopic direction indicator (or equivalent). These rely on a remote mounted magnetic flux indicator to measure the direction of earth’s magnetic field and are located away from magnetic interferences common to the aircraft cockpit. Remote indicators are commonly located at the end of the wing or in the tail. If necessary, gyroscopic compasses are shielded from magnetic effects and are regarded as more reliable direction indicators than the magnetic compass (wet compass) located in the cockpit.

3.3 For most operations today, the magnetic heading (from either gyroscopically stabilized or magnetic compasses) is not used directly to navigate the aircraft. It is used as a cross-check to the navigation guidance (e.g. runway alignment). Transport aircraft and business aircraft typically do not use a magnetic instrument (cockpit mounted compass or gyroscopic compass) even for heading: they derive

true north from an inertial reference unit or attitude and heading reference unit, and then a mathematical model to convert that true heading to a magnetic heading.

3.4 Aviation standards for aircraft compasses allow a 4 degree tolerance for uninstalled aircraft compasses and aircraft airworthiness regulations allow up to a 10 degree compass tolerance, after adjustment.

3.5 Each aircraft type has an approved minimum equipment list (MEL) identifying the instruments and equipment that are essential for safe operations under all operating conditions. DGAC is unaware of any aircraft for which the MEL identifies the magnetic compass as an essential piece of equipment. As such, having a properly functioning compass is not a condition for departure from an airport and it is believed any commercial aircraft, including those with a full complement of passengers, may depart even though the magnetic compass is inoperative.

4. MAGNETIC EFFECTS ON AIRCRAFT EQUIPMENT

4.1 Magnetic forces acting on aircraft components are derived from several potential sources — the earth's magnetic forces, electromagnetic forces from onboard electrical equipment and statically charged aircraft equipment, and permanent magnets present in aircraft equipment or cargo.

4.2 The earth's magnetic field strength is approximately 0.6 gauss but may vary depending on geographic location and other influences. There are diurnal (daily cycle) effects that are often in the 0.01 to 0.03 gauss range and may be as high as 0.06 to 0.07 gauss in some cases. Local magnetic or ferrous geological structures cause geologically isolated influences. The direction of magnetic force lines changes with the position on the earth's surface (compass declination). Solar flares have an effect that has been reported as high as 1.0 gauss in intensity.

4.3 The movement of electrons in wires of operating equipment, the presence of static charges on operating equipment and even personal electronic devices may produce electromagnetic interference signals that may affect aircraft systems. Aircraft equipment that uses electricity creates its own magnetic field. Rotary aircraft equipment such as a jet engine can produce an electromagnetic effect when a charge built up on jet rotors moves in a rotating motion. Unlike the field of a permanent magnet, an electromagnetic field may vary in strength over short intervals of time (e.g. as is the case of electrical devices powered by alternating current) and this oscillation can induce undesirable currents in aircraft electrical systems. In addition, equipment may be switched on and off over the course of a flight, thereby emitting a compass altering effect at one moment and none the next. For this reason systems such as the gyroscopic compasses (but not the wet compass) used on aircraft are required to be shielded from electromagnetic effects and sensing devices are located as far away from magnetic effects as possible.

4.4 As already noted, a metallic object can assume a magnetic field strength. Such a metal object is said to be a permanent magnet. The magnetic strength of a permanent magnet is constant over time. In addition to cargo that may have a magnetic field strength, electric motors on aircraft will have permanent magnets that could affect the magnetic compass reading as could metallic aircraft parts. Structural components of computer systems installed in modern aircraft are purported to have magnetic field strengths in the ICAO regulated range. Unlike electromagnetic fields which may vary over time, the magnetic field strength of permanent magnets does not vary over time and therefore stationary permanent magnets do not pose a risk of inducing erroneous currents in electronic equipment. For this reason permanent magnets only affect magnetic compasses and not other avionics equipment.

4.5 Magnetic field strength drops off rapidly with increasing distance.

5. CARGO LOCATIONS ON COMMONLY USED AIRCRAFT

5.1 As required by Part 7;2.10 of the Technical Instructions, magnetized material must be loaded to avoid a 0.418 A/m field strength (a field strength capable of causing a 2 degree deflection) at the compass location and at compass detector units. Compass detector units (i.e. remotely located magnetic flux indicators used to operate the gyroscopic compass) are typically located in the tail or the wing of the aircraft to avoid electromagnetic effects and are outside the bounds of concern.

5.2 To meet the ICAO stowage provisions, a magnetized material at the upper ICAO limit would need to be loaded at least 4.6 meters away from the magnetic compass. A magnetized material at the lower ICAO limit would have to be loaded a distance somewhat less than 2.1 m away from the compass. Most air carriers seem to treat all magnetized material as if its strength is at the upper limit and load these materials 4.6 m from the compass. Appendix B provides approximate distances between the magnetic compass and the centre of the closest ULD position for aircraft commonly used in cargo operations. Clearly, due to aircraft arrangements, it is not possible for a material with a strength at the lower ICAO limit to be located close enough to the compass to warrant concern. Further, it can be seen that in many cases the required separation distance for upper limit magnetized materials is frequently achieved by aircraft design.

6. MAGNETIZED MATERIAL INCIDENT DATA

6.1 There are no known air transport incidents attributable to magnetized material.

6.2 The United States transport experience is telling in that magnetized material in the range regulated by the ICAO Technical Instructions has not been subject to United States' domestic air transport requirements since 1985. While some shipments are consigned in accordance with the ICAO requirements and United States operators normally load these shipments as required by ICAO (i.e. more than 15 feet from the magnetic compass), most shipments of ICAO magnetized materials are believed not to be identified and, therefore, not subject to any special stowage requirements. A review of the United States DOT incident database indicated that no accidents involving magnetized material had been reported.

6.3 It is suspected that given the low magnetic field strength levels regulated by ICAO, there may be considerable non-compliance with the ICAO magnetized material requirements. A survey of some international shippers and carriers suggests that there is considerable confusion regarding the regulation of magnetized material and that some only treat goods as magnetized material when the 0.00525 gauss level at 4.6 m is exceeded. In other cases, non-compliance may be unwitting as metal objects may become magnetized unintentionally. In addition, items shipped under some shipping names may not be handled as magnetized materials. For example, while vehicles transported under UN 3166 commonly meet the magnetized material criteria, it is believed that most are transported with no indication of a magnetized material hazard. One company, recently becoming aware that its products met the Technical Instructions magnetized material criteria, estimates that over the past ten years, approximately 7000 undeclared international air shipments were made without incident.

6.4 Further, there are situations where the transport of several packages of materials not required to be declared as magnetized dangerous goods could in combination with other packages meet or exceed the ICAO limits. This is most likely to occur when a single shipper offers more than one package. Such a consolidated shipment would not be required to be declared as a magnetized material. Again no incidents involving such shipments are known to have occurred.

7. ACTION BY THE DGP-WG

7.1 The DGP-WG is invited to provide its input on the issues being considered and findings made to date with a view to DGAC completing the study in advance of DGP/22 and proposing amendments, as appropriate. The DGP-WG is also invited to consider what regulatory alternatives might be appropriate.

APPENDIX A

PROPOSAL CONTAINED IN DGP/17-WP/59

The following proposed changes made at DGP/17 had the intent of deregulating magnetic materials with a strength in the range of 0.159A/m at 2.1 m to 0.418 A/m at 4.6 m while maintaining the prohibition on transport of magnetic materials with a strength greater than 0.418 A/m (0.00525 gauss; a compass deflection of 2°) at 15 feet unless it was shielded.

The proposed changes were analogous to the following:

- a) delete Packing Instruction 902;
- b) delete Part 5;2.10;
- c) in Table 3-1, amend the Name column to read, Magnetized material, see Special provision A XXX;
- d) adopt a new special provision A XXX to read as follows:

“A XXX Magnetized material exhibiting a field strength exceeding 0.418 A/m at a distance of 4.6 m from any point on the surface of the assembled consignment is forbidden from transport.”
- e) delete Part 5;3.2.10 and figure 5-23.
- f) delete Part 7;2.10.

APPENDIX B

ESTIMATED DISTANCES BETWEEN WET COMPASS AND CENTER OF CLOSEST CARGO LOCATION ON AIRCRAFT COMMONLY USED FOR CARGO TRANSPORT

Aircraft	Estimated distance (compass to first cargo position)
A300-600	5.5 m
A300B4-200F	5.5 m
A310-200/300	5.5 m
ATR42-300/320	unavailable
ATR72-200	unavailable
B727	4.0 m
B747-100	3.0 m
B747-400	3.0 m
B757-200 Freighter	5.5 m
B767-300 Freighter	4.6 m
B777-Freighter	6.1 m
Cessna Caravan 208B	2.4 m
Cessna Caravan 208A	2.4 m
DC8	5.5 m
DC10-10	5.5 m
DC10-30	5.5 m
MD-11 Freighter	5.5 m
Fokker F27	4.2 m

Note.— Distance values are rough estimates taken from available aircraft schematic drawings of aircraft types known to be used for air cargo transport. Distances are from the assumed wet compass location and the centre of the closest unit load device.

— END —